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Pilot-Scale Treatability Test Plan for the 200-BP-5 Operable Unit

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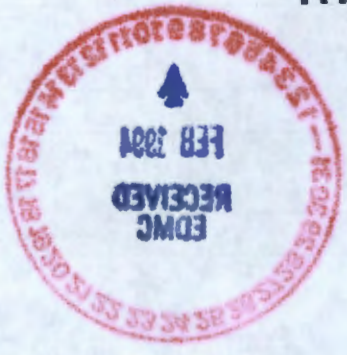

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EXECUTIVE SUMMARY

This document presents the treatability test plan for pilot-scale pump and treat testing at the 200-BP-5 Operable Unit. This treatability test plan has been prepared in response to a tentative agreement between the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the State of Washington Department of Ecology (Ecology), as documented in *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement, Ecology et al. 1989a) Change Control Form M-13-93-03, dated September 30, 1993. The tentative agreement also requires that, following completion of the activities described in this test plan, a 200-BP-5 Operable Unit Interim Remedial Measure (IRM) Proposed Plan be developed for use in preparing an Interim Action Record of Decision (ROD). The IRM Proposed Plan will be supported by the results of the testing described in this treatability test plan, as well as by other 200-BP-5 Operable Unit activities (e.g., development of a qualitative risk assessment). Once issued, the Interim Action ROD will specify the interim action(s) for groundwater contamination at the 200-BP-5 Operable Unit.

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The approach discussed in this treatability test plan is to conduct a pilot-scale pump and treat test for each of the two contaminant plumes associated with the 200-BP-5 Operable Unit. Primary contaminants of concern are ^{99}Tc and ^{60}Co for groundwater affected by past discharges to the 216-BY Cribs, and ^{90}Sr, $^{239/240}Pu$, and ^{137}Cs for groundwater affected by past discharges to the 216-B-5 Reverse Well. The pilot-scale treatability testing presented in this test plan has two primary purposes:

- To assess the performance of groundwater pumping with respect to the ability to extract a significant amount of the primary contaminant mass present in the two contaminant plumes.

- To assess the performance of aboveground treatment systems with respect to the ability to remove the primary contaminants present in groundwater withdrawn from the two contaminant plumes.

Implementing the two pilot-scale treatability test systems described under this treatability test plan will allow information to be gathered on the effectiveness, operating parameters, and resource needs of pump and treat as a potential interim action alternative. The overall scope of this test plan includes:

- Description of the pump and treat systems to be tested at each of the contaminant plumes, as well as the test performance objectives and data quality objectives (DQOs) that will be used to evaluate the effectiveness of the pump and treat systems.

- Discussion of the treatment technologies to be tested and supporting development activities, including laboratory treatability tests, process flow and conceptual design descriptions, and equipment, fabrication, utility, and system startup needs.

- Description of pump and treat system performance, operating procedures, and operational controls, as well as anticipated monitoring activities, analytes, parameters, analytical procedures, and quality assurance protocols.

- Summaries of other related treatability testing elements, including personnel and environmental health and safety controls, process and secondary waste management and disposition, schedule, and program organization.

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ACRONYMS AND ABBREVIATIONS

AAMSR	Aggregate Area Management Study Report
ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRDL	contract required detection limit
CRQL	contract required quantitation limit
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	State of Washington Department of Ecology
EII	Environmental Investigation and Instruction
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
IRM	interim remedial measure
K_d	soil-water distribution coefficient
M&TE	measuring and test equipment
msl	mean sea level
NPL	National Priorities List
NTU	nephelometric turbidity unit(s)
PARCC	precision, accuracy, representativeness, completeness, and/or comparability
ROD	Record of Decision
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

The 200 Areas of the Hanford Site (Figure 1-1) are included on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Hanford Site, established in 1943, was originally designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. Operations in the 200 Areas involved mainly separation of special nuclear materials from irradiated nuclear fuel and related chemical and fuel processing and waste management. In general, chemical and low-level radioactive liquid wastes associated with these operations were typically disposed to the ground via infiltration structures such as cribs, ponds, ditches, and injection wells resulting in groundwater contamination.

An aggregate area management study program was implemented under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement, Ecology et al. 1989a) to assess source and groundwater contamination in the 200 Areas. Based on the findings of the studies, an overall remedial action strategy for the 200 Areas was developed which favored the implementation of interim remedial actions to expedite the cleanup process. High priority groundwater contaminants were identified and interim remedial action recommendations were made following the *Hanford Past-Practice Strategy* (DOE-RL 1991). Recommendations were made based on the urgency for action and whether the nature and extent of the contamination was adequately understood to select and implement remedial actions.

The *200 East Groundwater Aggregate Area Management Study Report* (AAMSR) (DOE-RL 1993a) summarized information about groundwater contaminants beneath the 200 East Area and provided recommendations for prioritizing, investigating, and remediating various contaminants and plumes. The 200 East Groundwater AAMSR (DOE-RL 1993a) recommended that one contaminant/plume containing the highest concentrations of ^{90}Sr be addressed under an expedited response action (ERA), and that six other contaminants/plumes (^{60}Co, ^{99}Tc, ^{137}Cs, $^{239/240}Pu$, cyanide, and nitrate) be addressed under interim remedial measure (IRM) efforts. Discussions between the U.S. Department of Energy (DOE), the EPA, and the State of Washington Department of Ecology (Ecology) have resulted in an agreement in principle to address all seven contaminants/plumes under one of two IRMs in the 200-BP-5 Operable Unit. The ^{60}Co, ^{99}Tc, cyanide, and nitrate contaminants/plumes are associated with groundwater affected by past disposal practices involving primarily the 216-BY Cribs (the 216-B-43 through 216-B-50 Cribs, as well as the 216-B-57 and 216-B-61 Cribs), and will together be referred to as the "216-BY Cribs IRM plume" in the remainder of this document. The ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ contaminants/plumes are associated with groundwater around the 216-B-5 Reverse Well, and will together be referred to as the "216-B-5 Reverse Well IRM plume" in the remainder of this document.

The 200 East Groundwater AAMSR (DOE-RL 1993a, Section 7.0) provided an initial feasibility study that screened technologies for groundwater remediation in the 200 East Area and developed preliminary action alternatives. These alternatives include no action, institutional control,

pump and treat, treatment at point of use/discharge, and physical or hydraulic containment/control. Of these alternatives, pump and treat is considered to be an appropriate interim action alternative, considering the IRM goal of risk reduction. Pump and treat has been tentatively agreed upon by DOE, EPA, and Ecology for pilot-scale testing at the 200-BP-5 Operable Unit as documented in the Tri-Party Agreement (Ecology et al. 1989a) Change Control Form M-13-93-03, dated September 30, 1993. This tentative agreement also requires the preparation of an IRM Proposed Plan following completion of the pilot-scale treatability test, and clarifies that the primary contaminants to be addressed in the 200-BP-5 Operable Unit pilot-scale treatability test are ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, and $^{239/240}Pu$. Although the pilot-scale treatment system will be specifically designed to remove these radionuclides, the system will also be assessed for its effectiveness in removing secondary contaminants (e.g., cyanide and nitrate) known to exist in the groundwater. Treated groundwater will be returned to the aquifer within the boundary of the IRM plume from which it was withdrawn.

Although pump and treat is generally considered to be a viable means of reducing the mass of mobile contaminants in groundwater, numerous site-specific factors may influence the effectiveness and selection of pump and treat as an interim action alternative. The purpose of the treatability testing described in this test plan will be to assess the ability to meet test performance objectives, which include establishing effectiveness, operating parameters, and resource needs associated with extracting and treating the primary contaminants present in the 216-BY Cribs and the 216-B-5 Reverse Well IRM plumes. The test will also serve as a proof-of-principle demonstration, and establish engineering design values and functional costs to support the selection of an effective treatment technology.

Following the treatability test, an IRM Proposed Plan will be prepared to support an Interim Action Record of Decision (ROD) for the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes. The IRM Proposed Plan will be supported by the results of the treatability test and a qualitative risk assessment that will focus on the IRM contaminants. The IRM Proposed Plan will develop and evaluate a limited number of alternatives (e.g., pump and treat, hydraulic control, no action). The need for additional treatability testing, field characterization activities, or feasibility studies will be addressed in the IRM Proposed Plan and/or the Interim Action ROD. Once issued, the Interim Action ROD will address CERCLA standards, including satisfaction of applicable or relevant and appropriate federal and state requirements (ARARs), pertinent to implementing the required interim action(s). Any residual contamination not addressed in the Interim Action ROD should be addressed in the final remedy selection process.

It may be determined during treatability testing that pumping groundwater would not efficiently achieve a significant amount of contaminant mass reduction in the groundwater, thus indicating that the goal of an IRM, risk reduction, may not be best achieved by a pump and treat interim action alternative. Nevertheless, this treatability test plan anticipates the performance of treatment system testing for groundwater removed from the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes even though it is has not been determined whether pumping groundwater will effectively remove a

significant contaminant mass. The overall rationale for this approach is based on the following key reasons:

- Data on treatment effectiveness will be needed to support the evaluation of potential treatment technologies during development of interim action alternatives prior to a final IRM decision for the 200-BP-5 Operable Unit.

- Treatment system test results would be useable for other Hanford Site response alternative evaluations by providing effectiveness data on similar contaminants and media (e.g., ^{90}Sr present also in N Springs groundwater).

- Groundwater pumped to the surface to assess the ability to extract contaminants from the aquifer would be treated prior to return, which is consistent with a bias for action and the goal of risk reduction.

- Tri-Party Agreement (Ecology et al. 1989a) Change Control Form M-13-93-03 (September 30, 1993) requires that this treatability test plan "recommend treatability test(s) be performed for the most viable technology(ies)". This requirement is satisfied by the description of the anticipated treatment system testing provided in this treatability test plan.

This treatability test plan describes laboratory- and pilot-scale testing to be performed on groundwater in the 200-BP-5 Operable Unit. The approach is to conduct two, independent pilot-scale tests specific to the 216-BY Cribs IRM plume and 216-B-5 Reverse Well IRM plume. This document provides the purpose, scope, and objectives of the treatability testing; describes the test locations; discusses the treatment technologies chosen for the tests; describes the treatability test system design, operation, and monitoring; and includes a test schedule. This treatability test plan is a secondary document, as this term is defined in the Tri-Party Agreement (Ecology et al. 1989a). Following the completion of treatability testing, a treatability test report will be prepared summarizing the results of this study. Treatability testing is expected to be completed in 1995.

1.1 PURPOSE AND SCOPE

Pilot-scale treatability testing has been identified as a principal activity required to support an Interim Action ROD for the 200-BP-5 Operable Unit by providing critical information regarding groundwater treatment. The purposes of this pilot-scale treatability testing are

- To assess the performance of aboveground treatment systems with respect to the removal of ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, and $^{239/240}Pu$ from groundwater withdrawn from the 216-BY Cribs IRM plume and 216-B-5 Reverse Well IRM plume.

- To assess the performance of groundwater pumping with respect to the extraction of contaminant mass from the 216-BY Cribs IRM plume and 216-B-5 Reverse Well IRM plume.

This treatability test plan focuses on conducting the above performance assessments by gathering information on the effectiveness, operating parameters, and resource needs of pilot-scale pump and treat systems developed for the 216-BY Cribs IRM plume and 216-B-5 Reverse Well IRM plume.

The scope of this test plan includes the following:

- Descriptions of the pump and treat systems to be tested at each of the IRM plumes, and of the types of questions that must be answered to determine the effectiveness of pump and treat.

- Predictions, based on conceptual models of the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes, of the ability to achieve effective mass removal of contaminants from the IRM plumes.

- Definition of test performance objectives and DQOs that will be used to evaluate the effectiveness of the pump and treat systems.

- Discussion of the treatment technologies to be tested.

- A limited laboratory treatability test program to evaluate the effectiveness of a limited number of different ion exchange resins at removing the primary contaminants from 200-BP-5 Operable Unit groundwater samples.

- Development of process flows and conceptual designs for the pump and treat systems, as well as equipment, fabrication, utility, and setup needs for treatability testing.

- Description of anticipated pump and treat system performance, operating procedures, and operational controls.

- Anticipated monitoring activities, sampling locations and frequencies, analytes, parameters, analytical procedures, and quality assurance protocols.

- Description of personnel and environmental health and safety controls, including safe management and disposition of process and secondary waste streams.

- Presentation of a schedule and program organization for performing the treatability testing.

1.2 SITE DESCRIPTIONS AND CONTAMINANTS

In the 200 East Groundwater AAMSR (DOE-RL 1993a), recommendation of contaminant plumes for interim actions involved consideration of an initial risk-based screening as well as comparison of known contaminant concentrations in groundwater against pertinent federal and state groundwater standards. The

initial risk-based screening performed in the 200 East Groundwater AAMSR (DOE-RL 1993a) was designed to prioritize contaminant plumes on a consistent, semiquantitative basis for their relative intrinsic significance to human health. Overall, this risk-based screening was qualitative in nature and does not imply actual human health risks nor the existence of an exposure pathway. Strontium-90 was ranked highest in priority, followed by ^{99}Tc (ranked second), $^{239/240}Pu$ (ranked third), ^{137}Cs (ranked fifth), and ^{60}Co (ranked tenth), on the basis of their relative health risk indices. In addition, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, and $^{239/240}Pu$ were recommended for interim actions, because well-defined plumes were observed for which concentrations exceeded 1/25th (4%) of the administratively established Derived Concentration Guide (DCG) standards for groundwater (DOE Order 5400.5).

Based on the 200 East Groundwater AAMSR (DOE-RL 1993a) assessment, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, and $^{239/240}Pu$ presented high potential relative risk for their carcinogenic characteristics. Some groundwater samples have exceeded 4% of the DCG for ^{60}Co (200 pCi/L) by more than 2 times, for ^{90}Sr (8 pCi/L) by more than 500 times, for ^{99}Tc (4,000 pCi/L) by more than 5 times, for ^{137}Cs (120 pCi/L) by more than 10 times, and for $^{239/240}Pu$ (1.2 pCi/L) by more than 50 times.

The 200 East Groundwater AAMSR (DOE-RL 1993a) identified other contaminants and constituents in the groundwater. Secondary contaminants that exceed drinking water standards in the vicinity of the 216-BY Cribs IRM plume include cyanide and nitrate. A comprehensive list of groundwater contaminants and/or constituents encountered in the vicinity of the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes is provided in Appendix A.

The 216-BY Cribs and 216-B-5 Reverse Well IRM plumes are centered around two separate sites (Figure 1-2). The most recent summary of contaminant concentrations and distributions is presented in the *Groundwater Field Characterization Report for the 200 Aggregate Area Management Study* (Ford 1993), which provides the basis for the contaminant data summarized in Table 1-1 and the 216-BY Cribs and 216-B-5 Reverse Well IRM plume maps presented in Figures 1-3 and 1-4. Plume maps were generated on the basis of available data (i.e., Ford 1993) and computer contouring software. The data and software have inherent limitations on their ability to extrapolate plume boundaries. Figure 1-5 shows the major structures and facilities in the 200 East Area in relation to the two IRM plumes. Site descriptions and information about primary contaminant concentrations in the 216-BY-Cribs and 216-B-5 Reverse Well IRM plumes are provided below.

1.2.1 216-BY Cribs IRM Plume

The 216-BY Cribs IRM plume (Figure 1-3) is roughly centered around Well 699-50-53A, which is located about 2,900 ft north of the 200 East Area fenceline and about 3,000 ft north of the 216-BY Cribs (Figure 1-5). The area north of the 200 East Area fenceline is open, brushy terrain with no major impediments to the placement of a pilot-scale treatment system. All groundwater wells that would be used in this treatability test program are accessible. There are no utilities in this area.

The ^{60}Co and ^{99}Tc plumes (Figure 1-3) are defined on the basis of data from Wells 699-50-53A, 699-49-55A, 699-52-54, and 299-E33-7. These contaminant plumes are believed to extend for some distance to the west and south although well control is limited. In general, average ^{99}Tc concentrations range from about 1,000 to 19,169 pCi/L, with the highest average ^{99}Tc concentration measured at Well 699-50-53A. The highest average concentration for ^{60}Co (about 440 pCi/L) also occurs at Well 699-50-53A, with average ^{60}Co concentrations ranging down to about 28 pCi/L.

1.2.2 216-B-5 Reverse Well IRM Plume

The 216-B-5 Reverse Well IRM plume (Figure 1-4) is centered around the 216-B-5 Reverse Well, which is located about 1,000 ft northeast of the 221-B Canyon Building and about 100 ft east of Baltimore Avenue (Figure 1-5). Nearby facilities are the 216-B-9 Crib to the north and the 216-B-59 Retention Basin to the southeast. The projected surface expanse of the ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ plumes encompasses a level, open, brushy, surface contamination zone directly around the 216-B-5 Reverse Well, and a grassy uncontaminated area nearby. Other than the 216-B-5 Reverse Well surface contamination zone and risers associated with the 241-B-361 Settling Tank, 75 ft to the southwest, no potential obstructions to the placement of a pilot-scale treatment system are present.

The ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ plumes (Figure 1-4) are defined on the basis of data from Wells 299-E-28-7, 299-E-28-23, 299-E-28-24, and 299-E-28-25, and the plumes are believed to be relatively well confined to a small area centered around and slightly west of the 216-B-5 Reverse Well. In general, average ^{90}Sr concentrations range from about 76 to 5,149 pCi/L, with the highest average ^{90}Sr concentration measured at Well 299-E28-25. Average ^{137}Cs concentrations range from 10 to about 1,328 pCi/L, with the highest average ^{137}Cs concentration measured at Well 299-E28-23. The highest average concentration for $^{239/240}Pu$ (about 69 pCi/L) also occurs at Well 299-E28-23, with average $^{239/240}Pu$ concentrations ranging down to nearly zero.

1.3 GROUNDWATER CONCEPTUAL MODELS

The groundwater conceptual models presented below for the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes include information about contaminant sources, disposal practices, release mechanisms, affected media, exposure routes of receptors, and aquifer characteristics. These conceptual models were developed from data and information obtained from the *216-B-5 Reverse Well Characterization Study* (Smith 1980), the B Plant AAMSR (DOE-RL 1993b), the 200 East Groundwater AAMSR (DOE-RL 1993a), the *Hydrogeologic Model for 200 East Aggregate Area* (Connelly et al. 1992), the *Unconfined Aquifer Hydrologic Test Data Package for the 200 Areas Groundwater Aggregate Area Management Study* (Newcomer et al. 1992), *Groundwater Maps of the Hanford Site, December 1992* (Kasza et al. 1993) and the *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993c).

1.3.1 216-BY Cribs IRM Plume Conceptual Model

Beginning in about 1954, liquid process wastes were discharged to the soil column at the 216-BY Cribs, via the 216-B-43 to 216-B-50, 216-B-57, and 216-B-61 Cribs, located about 200 ft north of the 241-BY Tank Farm. Waste generated during ferrocyanide scavenging operations at U Plant to reduce the ^{90}Sr and ^{137}Cs content was sent to the 241-BY Single Shell Tank Farm from 1954 to 1957. About 8,940,000 gal of liquid waste was passed through a three-tank cascade system to settle out solids before being discharged to the soil column. Between 1965 and 1974, the 216-B-50 Crib received 16,000,000 gal of tank liquor condensate waste from In-Tank Solidification Unit 1 at the 241-BY Tank Farm (DOE-RL 1993b). Between 1968 and 1973, the 216-B-57 Crib received 22,000,000 gal of tank liquor condensate waste from In-Tank Solidification Unit 2 at the 241-BY Tank Farm (DOE-RL 1993b). Estimated quantities of primary contaminants discharged to the 216-BY Cribs are presented in Table 1-2.

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The 216-BY Cribs IRM plume is believed to have originated from liquid waste disposed at the 216-BY Cribs. The regional groundwater flow, influenced by the high-volume discharges to the 216-B-3 Pond (B Pond) System, has been primarily to the north and northwest, toward the Gable Gap-Gable Mountain area and past the 600 Area wells (Figure 1-3) north of the 216-BY Cribs. The present distributions of the ^{60}Co, ^{99}Tc, cyanide, and nitrate plumes have been generally described in Section 1.2.1 and presented in Figure 1-3.

The *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993c) also reported historically high levels of gross beta, ^{60}Co, ^{90}Sr, ^{137}Cs, nitrate, and tritium from the groundwater samples taken at both Wells 699-50-53A and 699-49-55A since initial sampling. The levels remained high through the 1950's and 1960's and then declined in the 1970's and early 1980's. Specific constituents such as chloride, ^{60}Co, nitrate, and sulfates then began to increase at Wells 699-50-53A and 699-49-55A from 1982 to 1986. Although groundwater data is lacking, ^{99}Tc and cyanide concentrations were also suspected to have increased at that time. Cesium-137 concentrations also increased at Well 699-49-55A in the same time period, but by 1987 ^{137}Cs concentrations had begun to drop at this well. Appendix A summarizes constituent concentrations between January 1, 1988 and January 1, 1994.

Estimates of IRM plume contaminant mass, based on information developed for the 200 East Groundwater AAMSR (DOE-RL 1993a), are presented in Table 1-2. The estimates for contaminant mass in the plumes are based on computer generated contours of groundwater sampling data and an assumed plume thickness of 33 ft. Information gathered by this treatability test program will be used to refine estimated plume and aquifer geometries and better define constituent mass distribution. As discussed in the 200 East Groundwater AAMSR (DOE-RL 1993a, Section 4.0), although contaminants have migrated from the 216-BY Cribs, they are confined to the groundwater and are not directly exposed to the surface environment. There are no known existing release exposure pathways and, currently, no known human or environmental receptors associated with the 216-BY Cribs IRM plume.

Well 699-50-53A has the thinnest (1.0 ft) saturated unconfined aquifer interval in the vicinity of the 216-BY Cribs IRM plume test area (Kasza et al.

1993). The well is located just south of a subsurface structural basalt high that extends above the current groundwater table north of the well. Wells 699-49-55A and 699-49-57A, located south and west of Well 699-50-53A, are situated in a thicker portion of the unconfined aquifer. Based on the most recent groundwater level measurements the saturated thickness is approximately 10 ft at Well 699-49-55A and about 9 ft at Well 699-49-57A. At both well locations, the screened interval is reported in the drilling logs to be a gravel unit above the top of the basalt.

Aquifer data in the vicinity of the 216-BY Cribs IRM plume is limited. However, based on the 200 East Groundwater AAMSR (DOE-RL 1993a), the hydraulic conductivity and transmissivity of the aquifer is expected to be relatively high. Specific information on well productivity and local water levels for the 216-BY Cribs IRM plume groundwater will be gathered as part of the treatability test.

Data presented in the 200 East Groundwater AAMSR (DOE-RL 1993a) suggests there is little tendency for ^{60}Co and ^{99}Tc to sorb to the fine-grained soil fraction in the Hanford formation. Cobalt-60 exists normally as a divalent cation in acidic to mildly alkaline solutions and is prone to sorbing onto soil via cation exchange. However, greater mobility is possible as ^{60}Co can form anion or neutral complexes. In particular, the association of ^{60}Co complexing with cyanide has been proposed as a means of explaining the observed mobility of ^{60}Co in the 216-BY Cribs IRM plume (DOE/RL 1993c). Technetium-99 typically forms negative ions in oxidizing environments and does not readily complex with other chemical species. Technetium-99 also has a low soil-water distribution coefficient (K_d). Consequently, there is little tendency for ^{99}Tc to sorb to the Hanford Site sediments making the radionuclide very mobile. Nitrate is a common byproduct from many of the past chemical processes (e.g., uranium recovery). It is widespread since it is highly soluble in water and forms a negative ion that is not easily adsorbed to the soil.

Based on the above geochemical information and current plume geometry, it is likely that ^{60}Co, ^{99}Tc, cyanide, and nitrate are relatively mobile in saturated zone soils. These conclusions, in conjunction with the likelihood of high aquifer conductivity, support a high probability that pumping the 216-BY Cribs IRM plume groundwater can result in the removal of a significant contaminant mass. This treatability test plan discusses monitoring and other activities that will be conducted during the pilot-scale pump and treat test to confirm this expectation.

1.3.2 216-B-5 Reverse Well IRM Plume Conceptual Model

The 216-B-5 Reverse Well was drilled in late 1944 and became operational as a low-level liquid waste disposal structure in April 1945. The reverse well received about 8,100,000 gal of effluent that was discharged into the groundwater before well abandonment on September 19, 1947. Included in the waste streams was an estimated 4,275 gm of $^{239/240}Pu$, 3,800 Ci of Beta emitters, 76 Ci of ^{90}Sr, 81 Ci of ^{137}Cs, and 160 Ci of ^{106}Ru (Maxfield 1979). Some of this material was retained (via gravity settling) in the 241-B-361 Settling Tank located upstream from the reverse well, but an estimated 2,000 gm of

$^{239/240}$Pu went into the well (Smith 1980). Estimated quantities of primary contaminants discharged to the 216-B-5 Reverse Well are presented in Table 1-2.

A previous investigation by Smith (1980) showed there was little migration of ^{90}Sr, ^{137}Cs, or $^{239/240}$Pu horizontally from the reverse well within the aquifer (Figures 1-6, 1-7, and 1-8). The current distributions of the ^{90}Sr, ^{137}Cs, and $^{239/240}$Pu plumes have been generally described in Section 1.2.2 and presented in Figure 1-4. Appendix A summarizes concentrations for other constituents detected in wells in the vicinity of the 216-B-5 Reverse Well. Estimates of the quantities of primary contaminants present in the 216-B-5 Reverse Well IRM plume are presented in Table 1-2. Strontium-90, ^{137}Cs, and $^{239/240}$Pu migration from the 216-B-5 Reverse Well has been minimal. As discussed in the 200 East Groundwater AAMSR (DOE-RL 1993a, Section 4.0), there are no existing release exposure pathways and, currently, no known human or environmental receptors associated with the 216-B-5 Reverse Well IRM plume.

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Historical groundwater level changes across the 200 East Area are attributed to the operation of the B Pond System, which has dominated the groundwater flow pattern in 200 East Area (DOE/RL 1993a). Since the start of discharges to the B Pond System in April 1945, area-wide groundwater table elevations have generally increased and the flow directions at the 216-B-5 Reverse Well have changed from an east to a northwest trend. Continuing discharges to the B Pond System have produced a significant increase in the elevation of the groundwater table, but done little to mobilize the primary contaminants. Of the three radioisotopes, ^{137}Cs appears to have been the most mobile at the time of discharge as it has spread over a relatively greater volume of the aquifer. The ^{90}Sr and $^{239/240}$Pu radionuclides are much less mobile and occupy roughly the same volume of the aquifer in similar distribution patterns as illustrated in Figures 1-6, 1-7 and 1-8. The relative immobility of ^{90}Sr and $^{239/240}$Pu is attributed to their adsorption to silt and clay particles in the sediment (Smith 1980).

Available information about the 216-B-5 Reverse Well indicates a contamination zone that developed when the waste stream containing ^{90}Sr, ^{137}Cs, $^{239/240}$Pu, and other radionuclides encountered the uppermost unconfined aquifer at the time of injection (Smith 1980). Some constituents such as ^{106}Ru, which are soluble in water, were quickly transported away from the well site or decayed. Less soluble radionuclide species (those with a high K_d value) sorbed to the silt and clay fractions of the Ringold gravels in the immediate vicinity of the well. Repeated injection of waste to the aquifer occurred coincidently with the early stages of groundwater table elevation increases attributable to the influence of the B Pond System operation. This resulted (by 1980) in a 6- to 10-ft thick zone of elevated ^{90}Sr, $^{239/240}$Pu and, to a lesser degree, ^{137}Cs concentrations (Figures 1-6, 1-7, and 1-8).

The contaminant IRM plumes are located in an aquifer that is under unconfined hydraulic conditions (Connelly et al. 1992). The bottom of the aquifer is basalt at an elevation of about 328 ft above mean sea level (msl). The aquifer is contained in the Ringold Formation Unit A. This unit is described by Lindsay et al. (1992) as being clast-supported granule to cobble gravel with a sandy matrix. The local elevation of the water table is approximately 402 ft above msl. The saturated thickness of the aquifer is

about 45 ft in the vicinity of the 216-B-5 Reverse Well. Flow direction is difficult to determine because of the very flat gradient in the local water table. Caggiano (1993) calculated a hydraulic gradient of 0.00006 in the vicinity of the BX-BY tank farms, 2,000 ft northeast of the 216-B-5 Reverse Well, with the flow being generally towards the northwest to north.

Aquifer transmissivity has been determined from data collected from a constant discharge test at Well 299-E28-27 (Newcomer et al. 1992), located approximately 2,200 ft northwest of the 216-B-5 Reverse Well. The transmissivity was determined to be greater than 48,000 ft^2/day, yielding an equivalent hydraulic conductivity of greater than 4,800 ft/day (based on local aquifer thickness). Connelly et al. (1992) shows the hydraulic conductivity for the area around the 216-B-5 Reverse Well as ranging between 5,000 and 10,000 ft/day. Using a known hydraulic gradient of 0.00006 and a conservative hydraulic conductivity value of 5,000 ft/day, and with an assumed effective porosity of 20%, an average linear velocity of approximately 1.3 ft/day can be calculated. This high velocity suggests that contaminants would tend to migrate rapidly unless sorbed to soil particles or flow is otherwise retarded.

Based on information in Appendix A, the groundwater pH ranges between 6.4 and 9.0 at the 216-B-5 Reverse Well. Plutonium-239/240 possesses significant sorption properties over a pH range of 4 to 8.5 in Hanford Site soils (DOE/RL 1993c). Above a pH of 8, $^{239/240}Pu$ is moderately mobile. Strontium-90 exists as a divalent cation within the pH range of groundwater (usually 6 to 8) and can sorb to Hanford Site soils by cation exchange over a pH range down to about 4 to 5. Sorbtion is also dependent on oxidation/reduction potential (eH); however, little information is available on eH conditions in Hanford Site soils. In a saturated environment, competition between ^{90}Sr and calcium-rich wastes may lead to greater apparent mobility for ^{90}Sr. Cesium-137 exists as a monovalent cation within the range of Hanford Site soil types and groundwater pH values and sorbs readily to soils by ion exchange down to a pH of 3. Sorption is also dependent upon the concentrations of other cations, which may explain the greater apparent mobility of ^{137}Cs at the 216-B-5 Reverse Well.

Based on the geochemical information presented above, it is likely that ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ are sorbed to saturated zone soils and are relatively immobile around the 216-B-5 Reverse Well. The evidence of a relatively high hydraulic conductivity and groundwater flow rate implies adequate opportunity existed for ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ to have migrated. Yet their distribution in the groundwater relative to their original disposal location indicates that ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ (Figures 1-6, 1-7, and 1-8) are not readily transported in groundwater but reflect the equilibrium of soil sorbed contaminants with groundwater. These conclusions support a high probability that pumping the 216-B-5 Reverse Well IRM plume groundwater is not likely to result in the extraction of significant contaminant mass.

This treatability test plan includes specific information needs and activities (as discussed in Sections 2.0 and 3.0) to be addressed during the pilot-scale pump and treat test to evaluate this conceptual model. The focus will be to determine if groundwater pumping can effectively extract primary contaminants present in the aquifer in the vicinity of the 216-B-5 Reverse Well.

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Figure 1-1. Hanford Site Location Map.

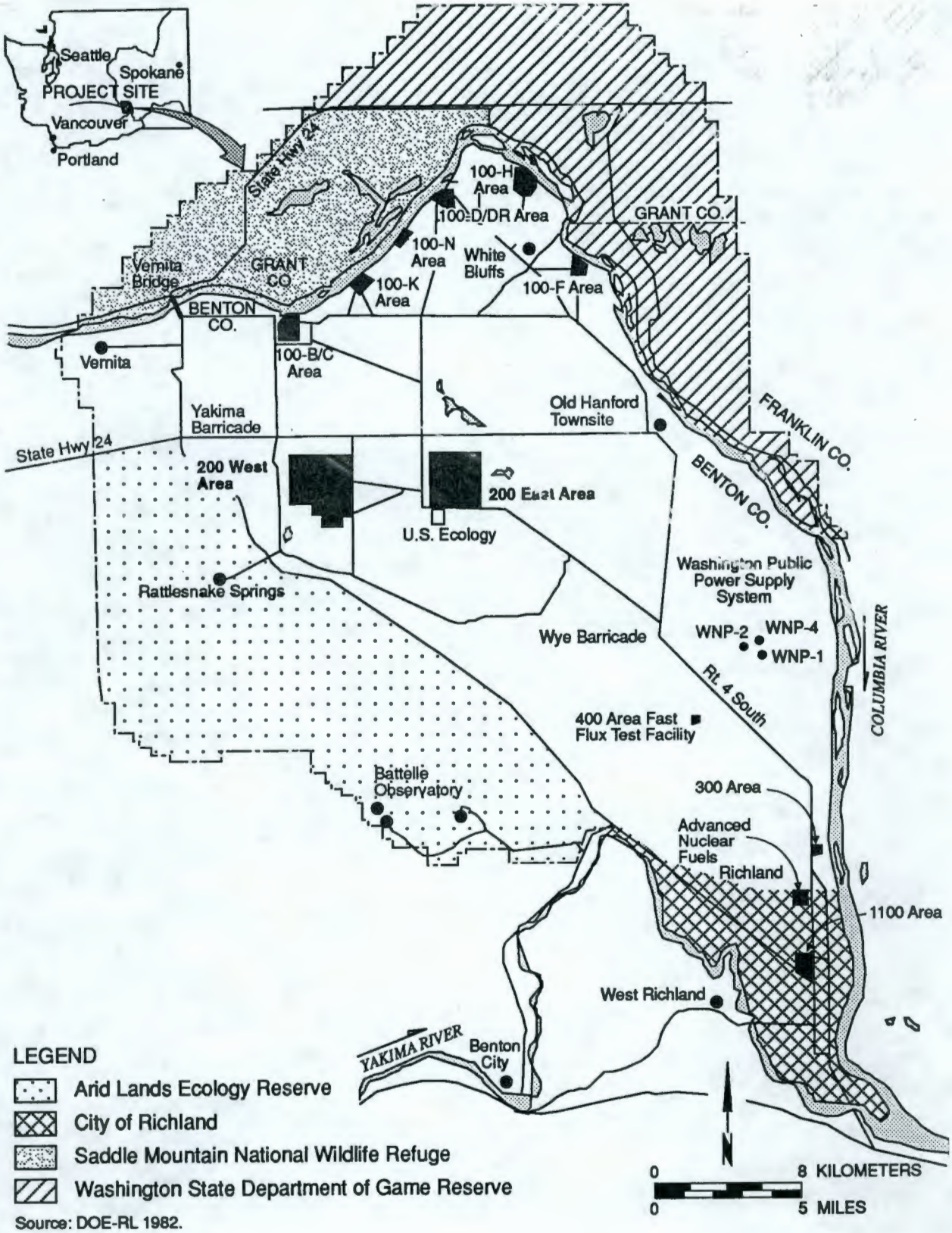

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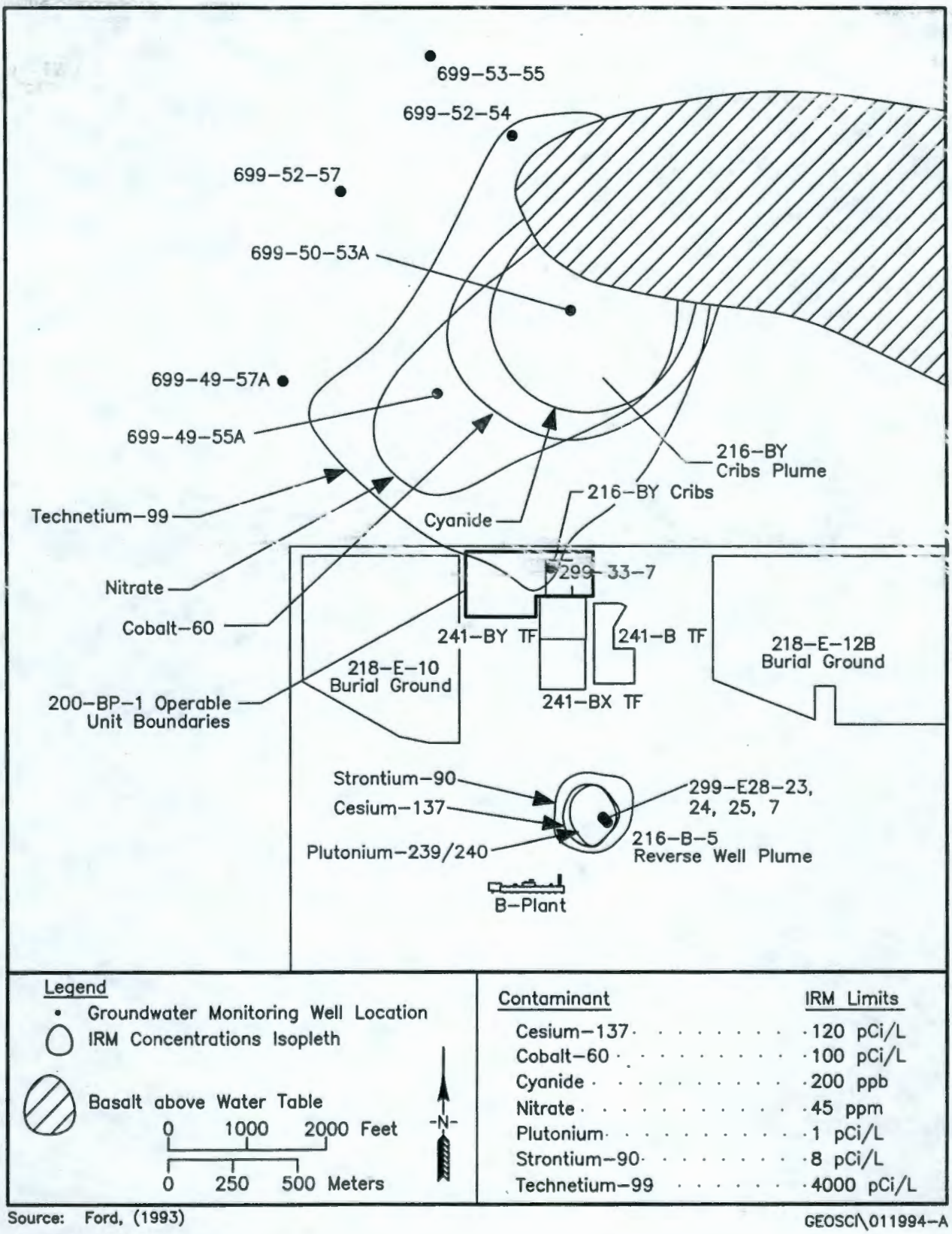
Figure 1-2. 200-BP-5 Operable Unit IRM Plumes Location.



Source: Ford, (1993)

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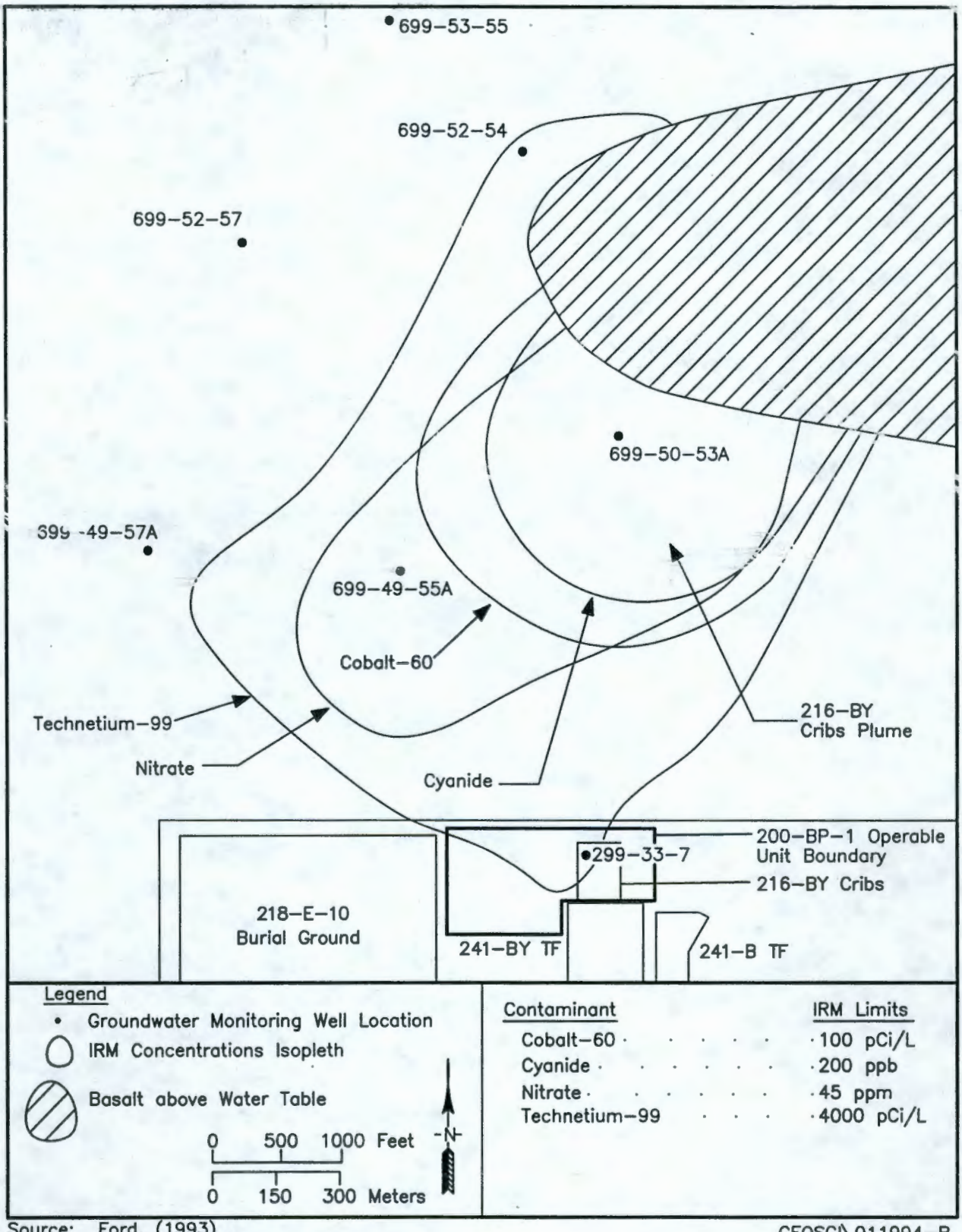
Figure 1-3. 216-BY Cribs IRM Plume.



Source: Ford, (1993)

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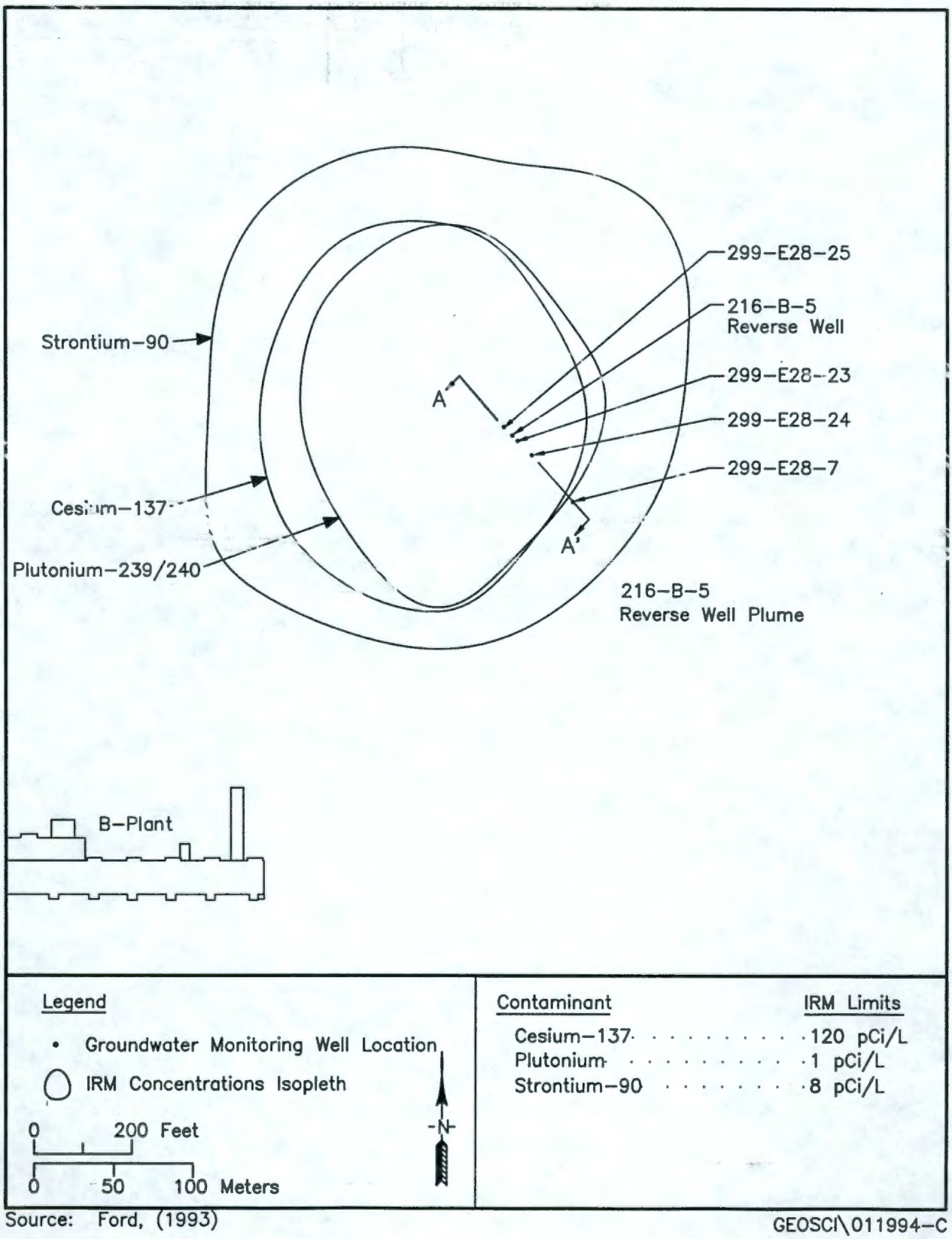
Figure 1-4. 216-B-5 Reverse Well IRM Plume.



Source: Ford, (1993)

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Figure 1-5. 200 East Area.

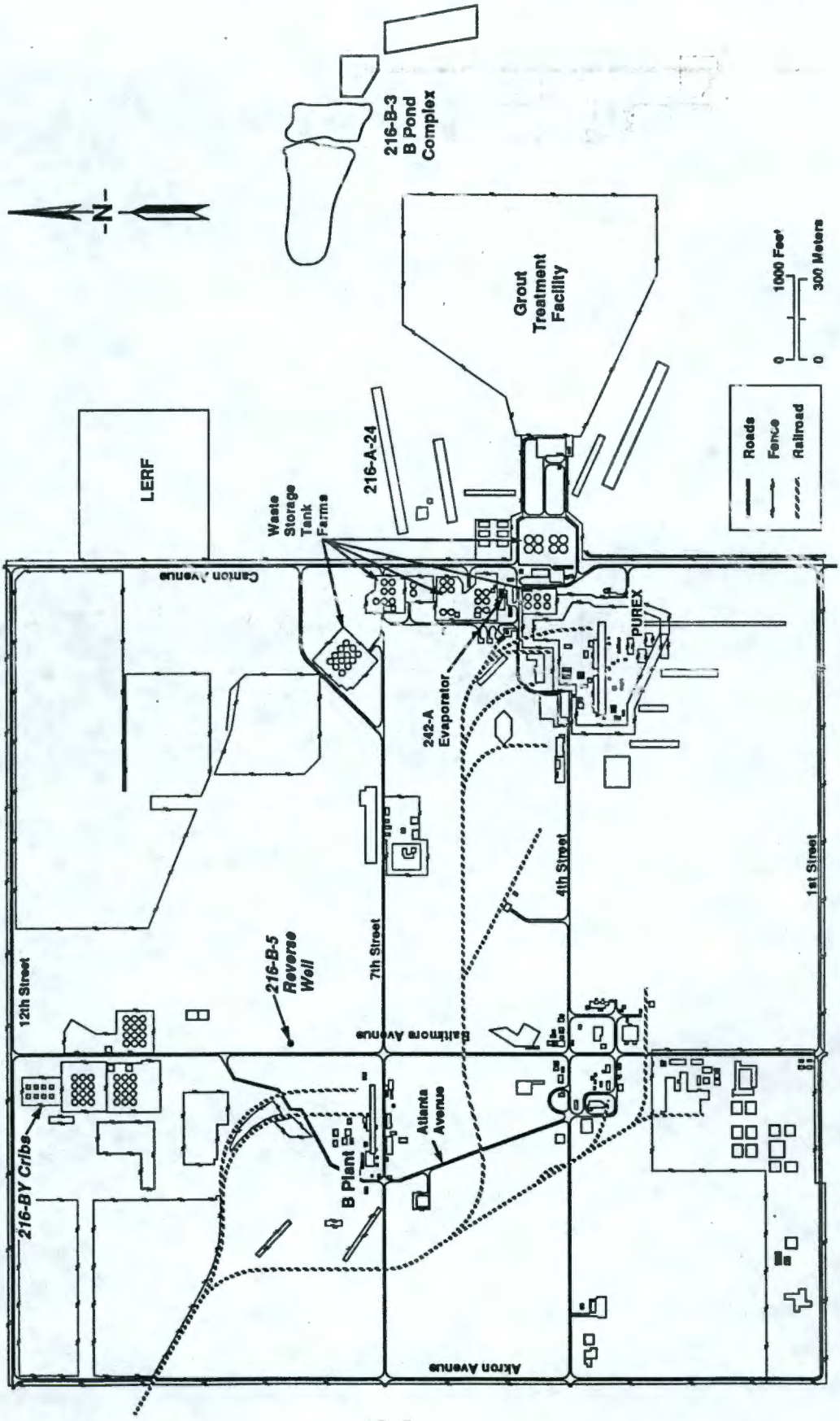

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Figure 1-6. Strontium-90 Plume (nCi/g) in the Vicinity of the 216-B-5 Reverse Well. (Smith, 1980)

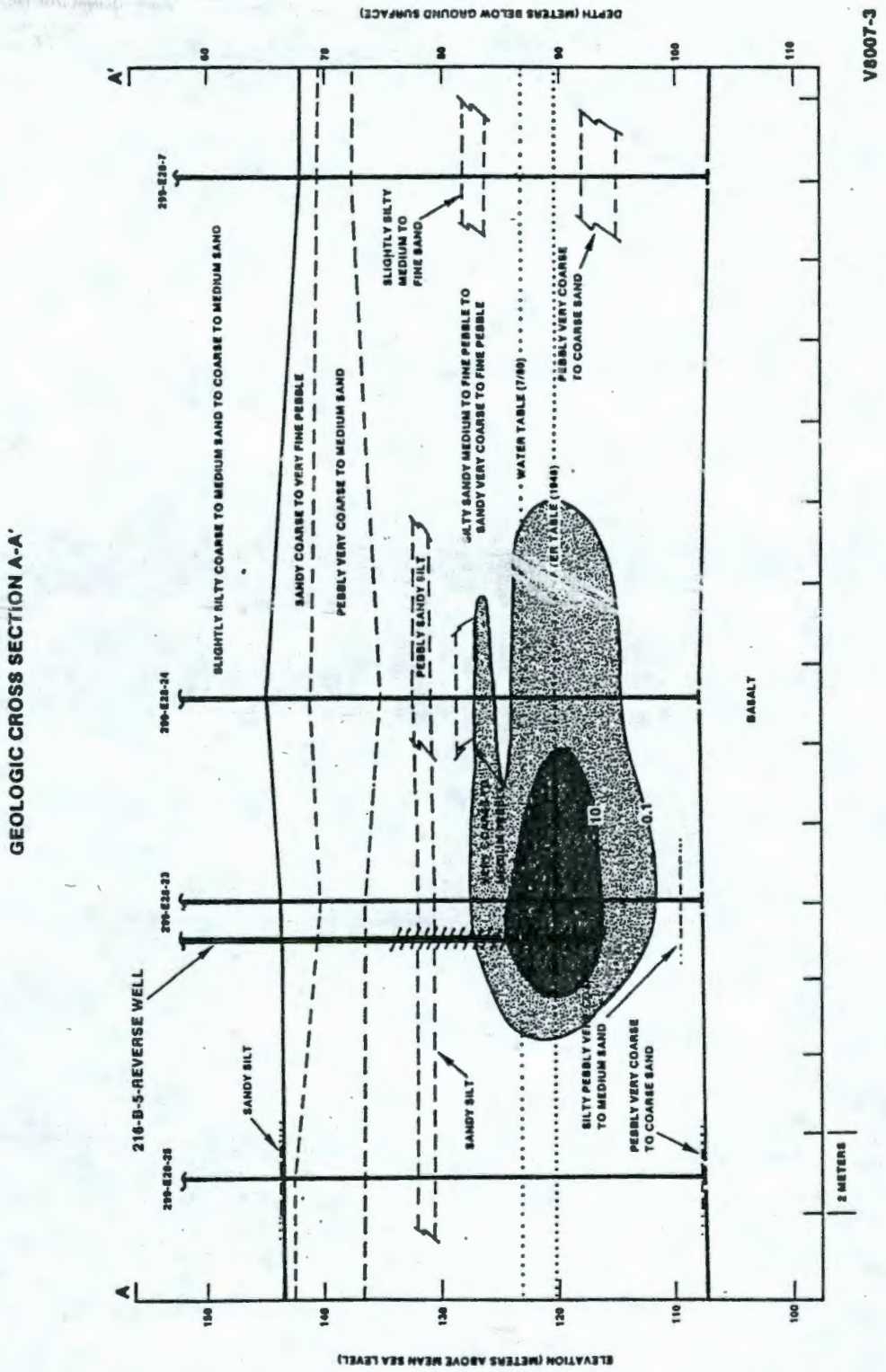

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Figure 1-7. Cesium-137 Plume (nCi/g) in the Vicinity of the 216-B-5 Reverse Well. (Smith, 1980)

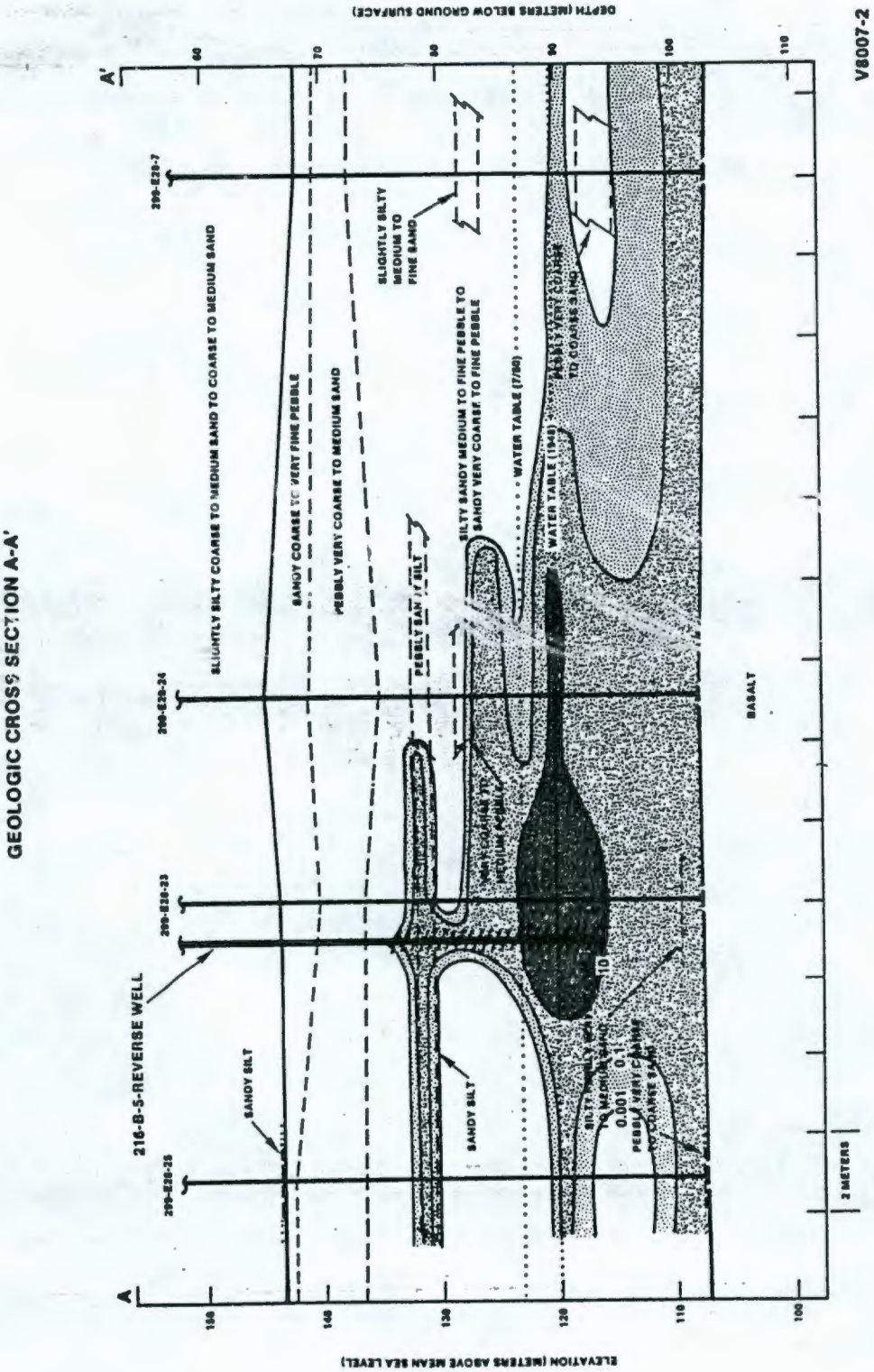

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Figure 1-8. Plutonium-239/240 Plume (nCi/g) in the Vicinity of the 216-B-5 Reverse Well. (Smith, 1980)

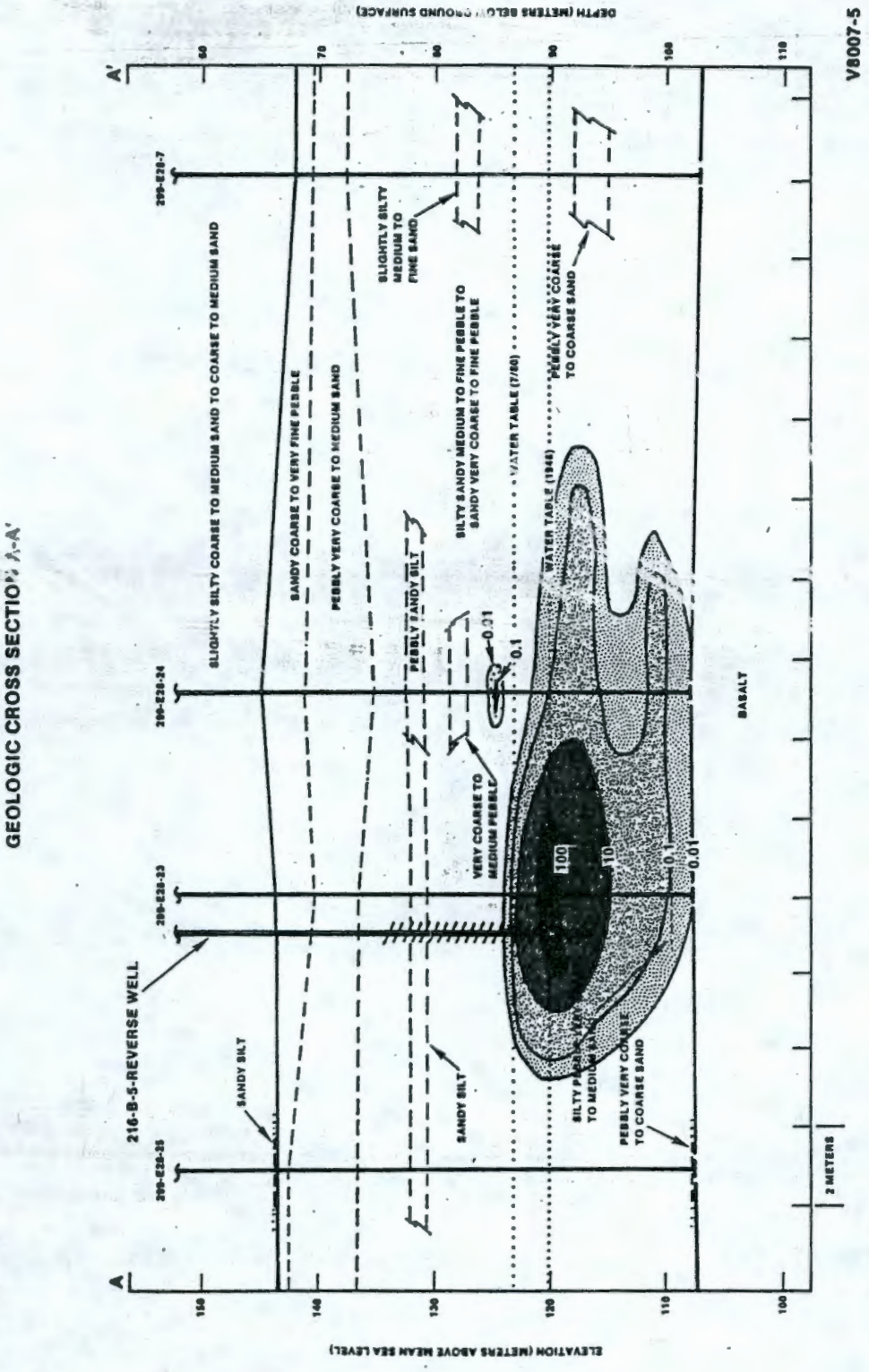

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Table 1-1. Summary of 200-BP-5 Operable Unit Contaminant Concentrations.

216-BY Cribs IRM Plume			Results Summary
Well	Contaminant	Units	Average
699-49-55A	Technetium-99	pCi/L	3120.56
	Cobalt-60	pCi/L	80.25
	Cyanide (Total)	ppb	59.10
	Nitrate	ppm	101.69
699-50-53A	Technetium-99	pCi/L	19169.10
	Cobalt-60	pCi/L	440.21
	Cyanide (Total)	ppb	893.20
	Nitrate	ppm	397.27
299-E33-7	Technetium-99	pCi/L	2152.86
	Cobalt-60	pCi/L	39.58
	Cyanide (Total)	ppb	33.60
	Nitrate	ppm	41.03
699-52-54	Technetium-99	pCi/L	1000.67
	Cobalt-60	pCi/L	26.10
	Cyanide (Total)	ppb	30.40
	Nitrate	ppm	0.59
216-B-5 Reverse Well IRM Plume			Results Summary
Well	Contaminant	Units	Average
299-E28-23	Strontium-90	pCi/L	4396.25
	Plutonium-239/40	pCi/L	68.75
	Cesium-137	pCi/L	1328.4
299-E28-24	Strontium-90	pCi/L	196.17
	Plutonium-239/40	pCi/L	34.37
	Cesium-137	pCi/L	112.31
299-E28-25	Strontium-90	pCi/L	5148.57
	Plutonium-239/40	pCi/L	16.67
	Cesium-137	pCi/L	246.53
299-E28-7	Strontium-90	pCi/L	75.59
	Plutonium-239/40	pCi/L	0.05
	Cesium-137	pCi/L	10.0

Source: WHC, 1993a, *Groundwater Field Characterization Report for the 200 Aggregate Area Management Study*, WHC-SD-EN-TI-020, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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Table 1-2. Summary of 200-BP-5 Operable Unit Conceptual Model Data.

Plume	Contaminant	Quantity disposed[a]	Dissolved Plume Quantity[b]	Half life (yr)[b]	Average Conc. in Max. well[c]	Drinking Water Standard	Mobility (K_d in mL/g)[b]	Primary Decay Mode[b]
216-BY Cribs IRM Plume	^{60}Co	0.45 Ci	0.43 Ci	5.3	369 pCi/L	100 pCi/L	Low (2000)	γ
	^{99}Tc	[unknown]	21.9 Ci	213,000	15,668 pCi/L	4,000 pCi/L	High (0)	β
	Cyanide	13,900 kg	985 kg	--	741 ppb	200 ppb	High (0.1)	--
	Nitrate	5,650,500 kg	740,000 kg	--	501 ppm	45 ppm	High (0)	--
216-B-5 Reverse Well IRM Plume	^{90}Sr	76 Ci	0.17 Ci	28.5	5028 pCi/L	8 pCi/L	Moderate (20)	β
	^{137}Cs	81 Ci	0.014 Ci	30	1546 pCi/L	120 pCi/L	Low (500)	γ (daughter product decay)
	$^{239/240}Pu$	2,000 gm (ca. 300 Ci)	0.0006 Ci	24,400/ 6,560	51 pCi/L	1 pCi/L	Low (2000)	α

SOURCES:

a Data on quantity disposed from Maxfield (1979), Smith (1980), and *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993c). Plutonium converted from mass to activity according to average specific activity for ^{239}Pu and ^{240}Pu; cyanide data converted from ferrocyanide data.

b Data on plume quantity, half life, mobility, and primary decay mode from *200 East Groundwater AAMSR* (DOE-RL 1993a).

c Data on average concentration in maximum well from Table 1-1.

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2.0 ALTERNATIVE AND TECHNOLOGY DESCRIPTION

A tentative change described in Tri-Party Agreement (Ecology et al. 1989a) Change Control Form M-13-93-03 (September 30, 1993) requires that the DOE begin pilot-scale pump and treat operations after August 31, 1994, in the 200-BP-5 Operable Unit. This treatability test plan outlines two pilot-scale pump and treat systems, one for the 216-BY Cribs IRM plume and one for the 216-B-5 Reverse Well IRM plume. This section describes pump and treat as a potential interim action alternative, including discussions of contaminant extraction from each of the IRM plumes and the treatment technologies to be tested. The purpose of these discussions is to generally delineate the major ambiguities for which test performance and DQOs should be developed (Section 3.0), and which the treatability test system should be designed and operated to accommodate (Section 4.0).

Specifically, Section 2.1 provides an overview of pump and treat, discusses the ability of the pump and treat alternative to effectively extract contaminants from the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes, and presents potential limitations that may be encountered and preliminary methodologies for responding to these potential limitations. Section 2.2 discusses the treatment and potential pretreatment technologies to be evaluated, the rationale for selecting them, and the major considerations that should be anticipated when developing a treatment system to effectively remove contaminants from groundwater after it has been pumped from the aquifer.

2.1 PUMP AND TREAT ALTERNATIVE

Pump and treat involves the withdrawal of contaminated groundwater, treatment above ground using appropriate pretreatment and treatment technologies (e.g., filtration and ion exchange), disposition of secondary waste streams, and disposition of treated groundwater via return to the aquifer or other methods. The pump and treat alternative has an added benefit in that the extraction of groundwater, as well as the selective return of treated groundwater, can be used to hydraulically control plume expansion. Pump and treat system effectiveness depends on a variety of factors, including aquifer properties, contaminant characteristics, and treatment system operating parameters. Treatment technologies have been shown to be effective at treating groundwater in which contaminants are relatively concentrated and mobile. For example, a previous groundwater remediation effort in the vicinity of U Plant in the 200 West Area demonstrated that ion exchange pump and treat can effectively remove uranium at high concentrations in the groundwater at that location (Delegard et al. 1986). However, treatment technologies become less cost effective as primary contaminant concentrations decline. In these cases, greater volumes of groundwater must be circulated through the system to remove an equivalent contaminant mass.

As discussed in Section 9.0 of the 200 East Groundwater AAMSR (DOE-RL 1993a), an IRM should not be undertaken to specifically meet cleanup limits or federal or state ARARs (e.g., maximum contaminant levels), but should be based on risk reduction. Under the IRM, the selected groundwater interim action should proceed until the response objective (e.g., reduction in risk) is met, a point of diminishing returns is reached, or natural

attenuation exceeds active treatment. The IRM should be discontinued if one of these conditions is met, and any residual contamination should be addressed in the final remedy selection process. This will be discussed in the IRM Proposed Plan and Interim Action ROD to be developed following completion of this pilot-scale treatability test program.

A pump and treat treatability test program should include an assessment of potential limitations of the aquifer/contaminant system on the success of pump and treat as an interim action alternative. These limitations generally fall into two categories: hydraulic, which affect the ability to withdraw contaminated groundwater from the aquifer at an effective pumping rate; and physical/chemical, which affect the ability of pumped groundwater to carry primary contaminants with it, thereby facilitating extraction of the contaminants from the aquifer. The conceptual models of the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes (Section 1.3) discussed the groundwater conditions and aquifer properties expected for the respective aquifer/contaminant systems. The following sections discuss the potential for hydraulic and physical/chemical limitations to be encountered for each of the IRM plumes and, if limitations are anticipated, methodologies for responding to these potential limitations.

2.1.1 216-BY Cribs IRM Plume Pump and Treat Alternative

As discussed in the conceptual model for the 216-BY Cribs IRM plume (Section 1.3.1), the primary contaminants in this IRM plume are very mobile, which accounts for their presence so far from the probable source of the contamination, the 216-BY Cribs. The only primary contaminant which does not have an inherently high mobility, as predicted by low K_d values (Table 1-2), is ^{60}Co. However, this plume constituent is thought to be complexed with ferrocyanide in such a way that it is also very mobile (DOE-RL 1993a). This would account for the apparent high mobility of ^{60}Co, as evidenced by its presence far from the contamination source and its spatial association with the cyanide plume. This high mobility indicates that the 216-BY Cribs IRM plume primary contaminants move with the groundwater. If the groundwater can be withdrawn from the aquifer through pumping, then it is expected that a significant amount of the total (adsorbed and dissolved) primary contaminant mass could also be brought to the surface to be treated.

One possible limitation for recovering primary contaminants from the 216-BY Cribs IRM plume is that the saturated thickness of the aquifer may be constricted in the vicinity of the IRM plume. If this limitation exists, even though the hydraulic conductivity is expected to be reasonably high, only a limited amount of groundwater could be produced by pumping a given well in this area. If this condition affects the ability to effectively extract a significant contaminant mass from the aquifer, it may be necessary during treatability testing to evaluate alternative wells, still in the central portion of the IRM plume, and their utility for achieving a more efficient pumping rate.

Methodology to address potential limitations will likely include hydraulic tests, such as well production tests, and stratigraphic interpretation. Groundwater primary contaminant concentrations will be

monitored to confirm the expectation that primary contaminants are being extracted with the pumped groundwater. However, monitoring and test activities already planned under the treatment system testing will be sufficient to assess the effectiveness of groundwater withdrawal and mass removal of primary contaminants from the 216-BY Cribs IRM plume.

2.1.2 216-B-5 Reverse Well IRM Plume Pump and Treat Alternative

As discussed in the conceptual model for the 216-B-5 Reverse Well IRM plume (Section 1.3.2), this IRM plume is present in a fairly thick and productive portion of the aquifer (thus easy to withdraw water from), but the primary contaminants are relatively immobile. Although groundwater has been measured to have primary contaminants present at concentrations above drinking water standards, a significant proportion of these same contaminants are adsorbed onto the soil particles in the aquifer. The two forms (phases) of the contaminants, adsorbed and dissolved, are expected to be in equilibrium in the saturated zone of the aquifer, with the K_d value (estimated in Table 1-2) representing the ratio between the concentrations in the two phases.

In addition, the 216-B-5 Reverse Well IRM plume is at or near the groundwater divide between the groundwater flow regime to the south and east, toward the Columbia River at a location near the 300 Area, and that to the north, through Gable Gap and toward the river near the 100 Areas. This groundwater divide is caused to some extent by the hydraulic influence of the B Pond System, where a large quantity of wastewater has been disposed of during much of the history of the Hanford Site. Because of the presence of the divide, groundwater gradients in the area of the 216-B-5 Reverse Well are very low. Consequently, groundwater flows through this contaminated portion of the aquifer have also been very low, and very little interchange has occurred with cleaner water coming in from other portions of the Hanford Site. This situation has resulted in the groundwater probably having had sufficient time to reach equilibrium with the primary contaminants in the aquifer soils.

When pumping for the treatability test begins, this equilibrium will begin to be disturbed. Initially, primary contaminant concentrations in the water withdrawn should be relatively consistent with historic groundwater analytical results. Approximate volumetric estimates, derived using information from Smith (1980) and Ford (1993), indicate that there may be on the order of 3,000 to 30,000 gal of water contaminated at the highest historically measured concentrations (e.g., in the range of 5,000 pCi/L for ^{90}Sr). After this highly contaminated groundwater is pumped, other, less contaminated water will flow into the area from beyond the highly contaminated zone. To some extent, this water will desorb some portion of the primary contaminants as it passes through the contaminated aquifer, although the kinetics of the phase transformation (how quickly the contaminants come off the soil particles) is unknown at this time. If this transformation process is slow, concentrations of the primary contaminants in the extracted groundwater will steadily decrease. Concentrations should eventually approach a lower concentration limit that will depend on the partitioning of the primary contaminants between the water and soil particles (K_d value) and the rate at which the contaminants can desorb from the soil particles as surrounding cleaner groundwater is drawn through the aquifer and into the

well. In this event, concentrations would return to the historically higher levels only by stopping the pumping and thereby allowing sufficient residence time for the phase transformation (i.e., desorption and equilibration) to occur between the inflowing groundwater in contact with the contaminated aquifer soils.

It is the objective of contaminant extraction testing to determine the feasibility of pump and treat technology to extract contaminants from the 216-B-5 Reverse Well IRM plume. In addition to the ability to effectively recover the primary contaminants from the aquifer materials in the 216-B-5 Reverse Well IRM plume, the hydraulics of removal (associated with the ability to pump a sufficient quantity of groundwater) will need to be evaluated. This will require development of aquifer parameters, which will be linked inherently with the assessment of the ability to extract and recover the primary contaminants. These assessments will require development of the following:

- appropriate pumping regimes, including cycling times (periods of pump shutdown time before restart of pumping), pumping locations (selection of wells), and pumping rates

- suitable (optimized) locations for treated water return to the aquifer

- an accurate interpretation of the hydrogeologic system, including the likely need for a computer model, using a system such as PORFLO3, of the hydrogeology and the contaminant transfer and transport phenomena at the site.

After the extraction (and return) system is optimized, it will then be appropriate to determine the long-range effectiveness of the pump and treat alternative.

Methodology to address effectiveness of pump and treat for the 216-B-5 Reverse Well IRM plume will likely include a number of hydraulic tests, such as pump tests and slug tests, and stratigraphic interpretation. Groundwater primary contaminant concentrations will be monitored to assess effectiveness of primary contaminant mass removal by the pilot-scale pump and treat system. Test performance and DQOs associated with contaminant extraction testing are addressed in Sections 3.1.2 and 3.2.2, respectively. Specific contaminant extraction test activities, including test design, operation, and monitoring, are described in Section 4.2.

2.2 TREATMENT TECHNOLOGY

Ion exchange will be implemented as the treatment technology for each of the two IRM plumes in the 200-BP-5 Operable Unit pilot-scale groundwater treatability test. Ion exchange is a unit process that removes dissolved radioactive and nonradioactive ions (e.g., ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, $^{239/240}Pu$, cyanide, and nitrate) from an aqueous solution (e.g., groundwater) by exchanging the ions with complementary ions attached to sites on the surface of an insoluble support material (typically, beads of synthetic organic

resin). In cation resins (designed to remove positively charged ions), the exchange sites usually contain hydrogen ions, but they may also contain sodium or ammonium ions. In anion resins (designed to remove negatively charged ions), the exchange sites usually contain hydroxide ions, but other ions such as chloride can be used. The ion exchange resin(s) that will be used for this treatability test will be selected based on the ability to selectively adsorb ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, and $^{239/240}Pu$. Contact between the ion exchange resin and the groundwater is achieved by the groundwater flowing through a vessel filled with resin.

Section 2.2.1 summarizes the rationale for identifying ion exchange as the treatment technology to be used in the treatability test. Section 2.2.2 describes the ion exchange process, and potential and planned pretreatment processes as they will be applied to treat ^{60}Co and ^{99}Tc in groundwater pumped from the 216-BY Cribs IRM plume and to treat ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ in groundwater pumped from the 216-B-5 Reverse Well IRM plume.

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2.2.1 Treatment Technology Identification

The primary reason for identifying ion exchange is that the technical literature, test and operating experience, and professional judgement indicate it will be effective in treating primary contaminants in both of the IRM plumes. EPA evaluations of treatment at radioactively contaminated Superfund sites (EPA 1990), previous treatability studies at the Hanford Site (Delegard et al. 1986; Barney et al. 1992), operating experience at the Oak Ridge National Laboratory (Robinson 1990), and numerous municipal and industrial water treatment applications (Baker et al. 1988, Sorg 1989, 1991; Jelinek and Sorg 1988; and Del Cul et al. 1992) have shown that ion exchange is a mature and effective technology for selectively removing radionuclides from both wastewater and groundwater. Although the concentrations of contaminants were generally higher and the concentrations of potentially interfering constituents were generally lower in these applications compared with those measured in the two 200-BP-5 Operable Unit IRM plumes, the results indicate that ion exchange will be effective in removing the ^{60}Co and ^{99}Tc contained in groundwater withdrawn from the 216-BY Cribs IRM plume and the ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ contained in groundwater withdrawn from the 216-B-5 Reverse Well IRM plume.

If larger-scale operation is required in a future treatment system, the scaleup parameters for ion exchange systems are well defined. Ion exchange systems have been used to treat aqueous streams with large flow rates. Thus, if it is decided to further develop ion exchange, as a potential interim action alternative, scaleup to support detailed evaluation and/or design of a full-scale system will be a straightforward process.

In ion exchange, contaminants are adsorbed and, thus, immobilized on the surface of the solid resin. In applications such as this treatability test, where "spent" resin (i.e., resin that has reached its practical adsorption capacity) is removed from the system for disposal, contaminants leave the system fixed in a stable secondary waste matrix that will resist leaching and minimize risk from transportation mishaps, thus minimizing the possibility of future contamination or recontamination of the environment. Additionally,

final waste handling and disposal are straightforward operations. After spent resin is transferred from the vessel and dewatered, it is expected to meet low-level waste acceptance criteria for long-term storage and/or final disposal. Facilities and expertise exist for transferring, dewatering, packaging, storing, and disposing of spent resin.

The mechanical simplicity of ion exchange technology combined with the ready availability of design expertise and standard equipment support expeditious design, construction, and operation of pilot-scale ion exchange treatment systems for the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes. Rapid deployment will be more consistent with achieving early risk reduction, thus furthering the primary goal of the IRM. The project plan is to construct skid-mounted systems that can be easily adapted to changes in test site locations, groundwater conditions (e.g., flow rates, contaminant concentrations), or treatability test DQOs.

2.2.2 Treatment Technology Description

Ion exchange resins will have a finite adsorption capacity for primary contaminants, related to the number of available ion exchange sites. A distinct advantage of ion exchange is that resin manufacturers have produced a wide variety of resins that can be very selective for targeted ion(s). However, the primary contaminants still may have to compete with other ions found in groundwater for these exchange sites. Because the concentrations of the primary contaminants are several orders of magnitude less than those of other groundwater constituents (e.g., cyanides, nitrates, sulfates) in this treatability test, competing ionic species may determine resin exhaustion rates.

When the resin is spent, breakthrough will occur. Breakthrough is the point in the resin loading cycle when the concentration of any one of the primary contaminants rises to a predetermined concentration in effluent from the resin bed. In designing an ion exchange system it is important to select resins which optimize adsorption of the primary contaminants and maximize the time to breakthrough. This will be accomplished through laboratory testing as described in Sections 3.0 and 4.0.

2.2.2.1 216-BY Cribs IRM Plume Treatment. Typically, an ion exchange treatment system includes one or more pretreatment units to condition the stream for optimum performance in the ion exchange unit. The pilot-scale treatment system to be implemented for testing at the 216-BY Cribs IRM plume will include filtration and pH adjustment units for pretreatment. Depending on results of laboratory tests to be conducted as part of this treatability test, the system may also include a pretreatment system for destroying cyanide.

The chemical state of the ^{60}Co in the 216-BY Cribs IRM plume is not known with complete certainty. It may be present as simple cations or anions that will adsorb readily onto cation or anion resin, respectively. However, as discussed in Section 1.3.1, there is evidence that ^{60}Co may exist in a neutral complex with cyanide. The complexed state could pose potential difficulties in treating ^{60}Co using ion exchange. If laboratory-scale tests

indicate that the ^{60}Co can be treated by either anion or cation exchange, no additional treatment will be required. However, if ion exchange is not effective, then a cyanide destruction pretreatment process may be required to break the ^{60}Co/cyanide complex and convert the ^{60}Co to a form amenable to ion exchange. As a contingency, a preliminary design is being developed for a cyanide destruction pretreatment process. This process, described in more detail in Section 4.3, will be an alkaline chlorination process, developed on the basis of literature (Patterson 1985) and engineering experience. If it is necessary to implement this process as part of the treatability test, the laboratory tests will provide information useful in verifying and optimizing design and operating parameters for the pretreatment system. If cyanide destruction is required, the treatment system will be configured so that cyanide destruction precedes ion exchange.

A filtration unit will be incorporated as a pretreatment technology to remove suspended solids contained in the groundwater before it enters the leading ion exchange bed. This pretreatment will minimize the potential for any inert and/or biologically active suspended solids to accumulate on the resin surface, masking the exchange sites, and resulting in loss of exchange efficiency. It will also minimize the potential for solids to plug the void spaces among the beads of resin and restrict flow through the bed. Furthermore, because many of the constituents in Hanford Site groundwater have an affinity for the soil, there is the potential for removing contamination associated with the inert, suspended solids.

A second filtration unit will be incorporated downstream of the ion exchange vessels to remove any suspended solids that may be formed by biological activity in the system, oxidation of dissolved species by exposure to the atmosphere, and/or by the addition of chemicals for pH adjustment or cyanide destruction. For example, adding sodium hypochlorite during alkaline chlorination will result in oxidation of any dissolved ferrous iron or manganous manganese to form insoluble precipitates. This downstream filtration will minimize any potential for plugging the return wells.

Experience indicates that the pH of the aqueous stream can affect selectivity of a given ion exchange resin for a given ion. Thus, a pH adjustment system will be included as a pretreatment process in the treatment system to support optimization of stream pH. The pH adjustment system will include means for adding sodium hydroxide to increase pH (or hydrochloric acid to reduce it) before the stream enters the ion exchange vessels and to neutralize the pH before the stream is returned to the aquifer.

2.2.2.2 216-B-5 Reverse Well IRM Plume Treatment. The ion exchange treatment process for removing ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ from groundwater extracted from the 216-B-5 Reverse Well IRM plume will be configured essentially the same as the process described in Section 2.2.2.1 for treating groundwater from the 216-BY Cribs IRM plume. Specifically, the treatment system will include the basic ion exchange unit as well as the pH adjustment and filtration pretreatment steps described above. However, depending on the results of laboratory tests, different ion exchange resin(s) may be used to provide enhanced selectivity for ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$. Also, it is not anticipated that any pretreatment will be required beyond the pH adjustment, neutralization, and filtration steps described in Section 2.2.2.1. Since no

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ionic complexing is evident for primary contaminants in this IRM plume, pretreatment of the type described in Section 2.2.2.1 for cyanide destruction is not anticipated.

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3.0 TREATABILITY TEST PERFORMANCE AND DATA QUALITY OBJECTIVES

Test performance objectives and DQOs are used to clarify and guide the testing process and to outline the quality and quantity of data needed for this treatability test program. Test performance objectives identify information needs required to evaluate the pilot-scale pump and treat alternatives. The DQOs link the information requirements with the intended data use to define the level of quality required for the measured variables. Data quality needs are defined by specifying precision, accuracy, representativeness, completeness, and/or comparability (PARCC) requirements.

There are two overall questions that this treatability test plan seeks to answer and that consequently affect the test performance objectives and DQOs presented in this section:

- Can the treatment and potential pretreatment technologies identified in Section 2.0 effectively reduce concentrations of ^{99}Tc, ^{60}Co, ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ in groundwater pumped from the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes?

- Can groundwater pumping effectively extract ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ from the 216-B-5 Reverse Well IRM plume?

This treatability test plan describes a number of test and development steps, including laboratory tests, pilot-scale treatment testing, and aquifer assessments, intended to answer the above questions. The following sections describe the test performance objectives and DQOs for these elements of the treatability test program. Given the relative similarities in the primary contaminants and anticipated treatment systems at the 216-B-5 Reverse Well IRM plume and the 216-BY Cribs IRM plume, the same treatment test performance objectives have been developed for and will be applied to the treatment systems under consideration. However, separate DQOs have been developed for the two IRM plumes to facilitate developed of detailed design, operating procedures, and monitoring activities. Test performance objectives and DQOs for contaminant extraction testing are discussed only for the 216-B-5 Reverse Well IRM plume.

3.1 TEST PERFORMANCE OBJECTIVES

Test performance objectives are typically most useful when comparing two or more distinct technologies available for use with a given problem or contaminant. However, they also have use in stating the overall objectives for this treatability test plan and helping to define the DQOs. The following sections present the test performance objectives for evaluating the pilot-scale treatment systems to be tested at the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes, and the test performance objectives for contaminant extraction from the 216-B-5 Reverse Well IRM plume aquifer.

3.1.1 Treatment Test Performance Objectives

The primary test performance objective for the pilot-scale treatment systems is to determine the removal efficiency that can be achieved for the primary contaminants ^{60}Co and ^{99}Tc in groundwater extracted from the 216-BY Cribs IRM plume, and ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ in groundwater extracted from the 216-B-5 Reverse Well IRM plume. Test performance objectives are divided into three categories: measurement of the effectiveness of ion exchange treatment; assessment of parameters or factors influencing the ion exchange operation; and determination of the resource needs associated with the test. Specific objectives under each of the three categories include the following:

- Effectiveness
  - Determine the effectiveness of the ion exchange system to consistently remove ^{60}Co and ^{99}Tc (or ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$) from the groundwater.
  - Identify optimum/preferred ion exchange resin(s) for removing ^{60}Co and ^{99}Tc (or ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$).
  - Assess the impact and removal of nitrate as a secondary contaminant in both IRM plumes.
  - Determine if ^{60}Co in the 216-BY Cribs IRM plume is amenable to ion exchange treatment. If ion exchange is not effective, determine if alkaline chlorination can break the ^{60}Co/cyanide complex and convert the ^{60}Co amenable to subsequent ion exchange.
  - If cyanide destruction is required, assess design/operating parameters associated with removal of cyanide as a secondary contaminant of the 216-BY Cribs IRM plume.
- Operating Parameters
  - Refine operational configurations, requirements, and procedures.
  - Assess impacts of groundwater constituents on operational efficiency.
  - Assess operating parameters (e.g., flow rates, chemical doses, residence times, pH, oxidation/reduction potential) to optimize treatment efficiency.
  - Demonstrate operational reliability and safety of an ion exchange-based treatment system at a scale sufficient to allow scale up to a full-scale remedial system.

- Resource Requirements

  - Develop estimates of significant cost components, including equipment and material costs; resin contaminant exchange capacity, exhaustion rate, and cost; electrical power and utility costs; chemical costs and use rates; process residue and secondary waste management costs; maintenance requirements; and operator and personnel requirements.

  - Refine health and safety requirements.

3.1.2 Contaminant Extraction Test Performance Objectives

Contaminant extraction testing will be performed at the 216-B-5 Reverse Well IRM plume. It is anticipated that contaminant removal at the 216-BY Cribs IRM plume will not require testing beyond normal process monitoring as described in Section 4.3.4.1. Specific contaminant extraction test procedures are described in Section 4.2.

The primary test performance objective for the contaminant extraction portion of the treatability test in the 200-BP-5 Reverse Well IRM plume is to assess the potential for recovering the primary contaminants (^{90}Sr, ^{137}Cs, and $^{239/240}Pu$) which are in or associated with IRM plume groundwater, and, if recovery is possible, develop an estimate of the rate at which primary contaminants could be extracted from the aquifer. This primary objective also involves a number of ancillary objectives which will enhance meeting the ultimate objective. These objectives are grouped into three categories: measurement of the effectiveness of the contaminant extraction process; assessment of aquifer parameters or operational procedures to allow optimization of the contaminant extraction process; and determination of resource needs. Specific objectives under each of the three categories include the following:

- Effectiveness

  - Determine the effectiveness of contaminant recovery for the primary contaminants from the aquifer matrix during implementation of a full-scale pump and treat system.

- Parameters for System Optimization

  - Refine aquifer hydraulic properties, primary contaminant distribution properties, and estimates of total contaminant quantities, to allow prediction of long-term recovery effectiveness.

  - Optimize pump cycling (in regard to pumping rates, aquifer re-equilibration times, and moving pumping among available wells) to maximize recovery.

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- Develop a computer model of local groundwater flow and primary contaminant phase transformation and transport in order to estimate aquifer and geochemical parameters and predict long-term system performance.

- Resource Requirements

  - Develop estimates of significant cost contributors, including electrical costs of pumping, installation of additional wells, technical personnel time to interpret process effectiveness, and analytical costs.

3.2 DATA QUALITY OBJECTIVES

According to the EPA document *Data Quality Objectives for Remedial Response Activities* (EPA 1987) and as developed in the 200 East Groundwater AAMSR (DOE-RL 1993a), DQOs are qualitative and quantitative statements that specify the quality of data required to support remedial action decisions. DQOs are determined based on the end uses of the data to be collected. The end use of the treatability study data is to support the evaluation of alternatives that will be included in the IRM Proposed Plan. To ensure that data collected are of sufficient quality to evaluate the ion exchange treatment system, DQOs were developed. Expected users of the test data include the following:

- DOE, EPA, and Ecology remedial project managers

- DOE, EPA, and Ecology unit managers

- Westinghouse Hanford Company (WHC) remedial investigation coordinators.

Sections 3.2.1 and 3.2.2 discuss DQOs for the treatment testing and the contaminant extraction testing, respectively. Analytical levels specified in this test plan are based on McCain and Johnson (1990). The DQOs will be provided in the sampling and analysis final plan being developed for the treatability test. These DQOs may be refined as the test equipment design and laboratory testing are completed.

3.2.1 Treatment Data Quality Objectives

The importance and ramifications of the remedial decisions that will be made and supported using the treatability test data form the basis for defining appropriate DQOs. Because the data will be used to support the remedy selection process for an interim action, DQOs were defined that are less rigorous than those required to support final remedial decisions or remedial designs.

Data to assess treatment effectiveness and costs are considered critical to meeting the test objectives and require quantification with quality control checks (e.g., sample replication). The assessment of operating parameters will primarily support design optimization, which is considered to be less

critical. As a result, a qualitative engineering evaluation of operating parameters is required with a limited amount of quantification.

The test plan includes a combination of lower level (Levels I and II) and higher level (Levels III and V) analyses to obtain the needed data in a cost-effective manner. Field screening and field analysis techniques (Levels I and II) will be used for daily monitoring requirements or measurements to ensure quick turnaround times required for process control. A limited number of confirmatory (Levels III and V) analyses are identified for critical information (e.g., pre- and post-treatment concentrations of primary contaminants). Specific DQOs for the laboratory-scale testing and pilot-scale treatment tests on groundwater from the 216-BY Cribs and 216-B-5 Reverse Well IRM plumes are presented in Tables 3-1, 3-2, and 3-3, respectively.

3.2.2 Contaminant Extraction Data Quality Objectives

Data collected during contaminant extraction tests will be used to develop a numerical model of aquifer and primary contaminant response to groundwater removal and to optimize pilot-scale treatment alternative effectiveness. Field analytical data (field screening or field laboratory analysis) will be used to assess contaminant treatment effectiveness and is considered critical to meeting test objectives. These data will require quantification with quality control checks (confirmatory sampling) by Level III or Level V analyses. Specific DQOs for contaminant extraction testing are identified in Table 3-4.

3.3 ADDITIONAL DATA USES

In addition to meeting specific treatability test objectives, these data may also be used to satisfy other data needs or to support other interim action decisions (e.g., treatment of ^{90}Sr in groundwater at the N Springs Operable Unit) including the following:

- occupational health and safety
- risk assessment
- identification of additional characterization needs
- interim action design and objectives
- monitoring during interim actions
- additional treatability tests.

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Table 3-1. Data Quality Objectives for Laboratory-Scale Testing. (Sheet 1 of 2)

Activity	Determine the preferred test chemistry of ion exchange resin(s), coupled with pretreatment system chemistry if necessary, which is suitable for removing ^{60}Co and ^{99}Tc (or ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$) from groundwater.
Objectives	Identify the preferred ion exchange resin(s) effective at capturing ^{60}Co and ^{99}Tc (or ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$) from groundwater samples.
Prioritized Data Uses	To support pilot-scale treatment system design (i.e., resin selection and pretreatment requirements).
Appropriate Analytical Level or Implementation Guidelines	Protocols will follow established industrial standards or EPA methods. Some analyses may require method modification and/or development (Level V)
Parameters to be Obtained	Because of the limited scope of the laboratory testing program, the parameters to be obtained focus on the effectiveness of the resin and potential pretreatment processes as follows: <u>Resin selection:</u> • Concentrations of primary and secondary contaminants • pH, temperature, oxidation/reduction potential • Batch equilibria • Kinetics, rate of uptake <u>Pretreatment:</u> • Effect of pH adjustment on removal efficiency • Resin capacity and effectiveness in removing ^{60}Co with and without cyanide destruction pretreatment.

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Table 3-1. Data Quality Objectives for Laboratory-Scale Testing. (Sheet 2 of 2)

Required Detection or Measurement Limits

Analytical detection limits and DQO requirements (PARCC parameters) will be identified in the sampling and analysis plan and quality assurance project plan. These requirements will focus on the effectiveness of the processes being tested. The following are DQOs for Level III analyses:

Parameter	Method	CRDL/CRQL[a/]	Precision	Accuracy
^{60}Co	EPA 901.1	Variable	±20%	75-125%
^{90}Sr	EPA 905.0	Variable	±20%	75-125%
^{99}Tc	TC-01[b/]	150 pCi/L	±20%	75-125%
^{137}Cs	EPA 901.0	Variable	±20%	75-125%
$^{239/240}Pu$	SW-846 9310	15 pCi/L	±20%	75-125%
Cyanide	[c/]	10 µg/L	±20%	75-125%
Nitrate	EPA 300, 352.1, 353.3, 353.2, 354.1	100µg/L	±20%	75-125%

Critical Samples or Values

- ^{60}Co and ^{99}Tc (or ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$), cyanide, and nitrate concentrations in pre- and post-treatment samples, with and without cyanide destruction pretreatment.

Constraints

- Representative samples are required of groundwater from each of the two IRM plumes.

a/ CRDL = contract required detection limit
CRQL = contract required quantitation limit

b/ Per *Environmental Measurements Laboratory Procedures Manual* (DOE 1982).

c/ As specified in the Contract Laboratory Requirement's Statements of Work for inorganic analysis; all analytical methods, contract required detection limits, contract required quantitation limits, and precision and accuracy requirements shall be as specified therein without modification (DOE/RL 1993d).

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Table 3-2. Data Quality Objectives for 216-BY Cribs IRM Plume Treatment Testing. (Sheet 1 of 3)

Activity	Pilot-scale Treatability Test
Objectives	Assess effectiveness, operating parameters, and costs of using ion exchange to remove ^{60}Co and ^{99}Tc from extracted groundwater.
Prioritized Data Uses	Priority data uses are to support the selection of a preferred alternative for the 216-BY Cribs IRM plume.
Appropriate Analytical Level or Implementation Guidelines	Level I and II screening analyses will be used for process monitoring. As a minimum, ^{60}Co, ^{99}Tc, cyanide, and nitrate concentrations will be verified by limited Level III or V analyses. No validation (Level IV) data will be required since only interim action decisions are being supported. Requirements will be refined in the sampling and analysis plan and the quality assurance project plan.
Parameters to be Obtained	<u>Effectiveness:</u> • Influent and effluent concentrations of ^{60}Co, ^{99}Tc, cyanide, and nitrate <u>Operating Parameters:</u> • Process chemistry (e.g., total suspended solids, dissolved oxygen, sodium, chloride, sulfate, heavy metals, organics) • Flow rate • pH, temperature, turbidity, oxidation/reduction potential • Operating pressures, both differential and point • Chemical additive requirements <u>Resource Needs:</u> • Equipment/materials • Personnel and maintenance requirements • Secondary waste volumes and characteristics • Power and chemical usages • Onstream factors • Health and safety requirements, including field radiation monitoring • Other cost elements (e.g., mobilization, sample transport, analytical services, decontamination, residuals transport/treatment disposal.

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Table 3-2. Data Quality Objectives for 216-BY Cribs IRM Plume Treatment Testing. (Sheet 2 of 3)

Required Detection or Measurement Limits

- Effectiveness

Analytical detection limits for ^{60}Co, ^{99}Tc, cyanide, and nitrate must be able to detect expected effluent concentrations after 90% removal. Accuracy should be sufficient to support calculation of removal efficiency to ±1%. Other supporting documentation such as equipment data sheets may also affect final DQOs. Detection limits will be finalized and other PARCC parameters will be specified in the quality assurance project plan being developed for the treatability test. The following are DQOs for Level III analyses:

Parameter	Method	CRDL/CRQL[c]	Precision	Accuracy
^{60}Co	EPA 901.1	Variable	±20%	75-125%
^{99}Tc	TC-01[b]	150 pCi/L	±20%	75-125%
Cyanide	[c]	10 µg/L	±20%	75-125%
Nitrate	EPA 300, 352.1, 353.3, 353.2, 354.1	100µg/L	±20%	75-125%

- Operating Parameters

Process chemistry will be measured primarily to detect significant and/or unanticipated secondary impacts on system operation and efficiency. Analytical protocols will follow established vendor standards, industrial standards, or EPA practices. Other operating parameters will be measured as follows:

Parameter	Instrument	Range	Accuracy
Flow rate	meter	10-60 gpm	±1 gpm
pH	probe	0-14	±0.1
Oxidation/reduction potential	probe	100-1400 mV	±0.1
Temperature	thermocouple or thermometer	0-100 °C	±1 °C
Turbidity	meter	0-100 NTU[d]	±5 NTU
Differential Pressure	transmitter or gauge	0-30 lb/in^2	±0.5 lb/in^2
Point pressure	transmitter or gauge	0-100 lb/in^2	±1 lb/in^2

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Table 3-2. Data Quality Objectives for 216-BY Cribs IRM Plume Treatment Testing. (Sheet 3 of 3)

- Resource Needs

Resources will be monitored in accordance with normal recordkeeping practices (e.g., inventory, manhours) specific to each resource type. EPA guidance calls for an accuracy of +50% to -30% in estimating implementation costs.

Critical Samples or Values

- Cobalt-60 and ^{99}Tc concentrations in influent and effluent streams at a frequency proportional to the rate of change in the primary contaminants
- If cyanide destruction is required, ^{60}Co and cyanide concentrations before and after pretreatment
- Chemical and radiological concentrations in spent resins and discarded filter cartridges
- Operating costs (e.g., materials, personnel)
- Secondary waste disposal costs.

Constraints

- It is necessary that resin breakthrough be measured in a timely manner for both ^{60}Co and ^{99}Tc.
- Representative samples are required of process water streams, discarded filter cartridges, and spent resin.
- Groundwater monitoring is required to verify that the pumped water is representative of site conditions.
- Some resin and filter cartridge samples may have high radionuclide content and may require special sampling and handling methods.

a/ CRDL = contract required detection limit
CRQL = contract required quantitation limit

b/ Per *Environmental Measurements Laboratory Procedures Manual* (DOE 1982).

c/ As specified in the Contract Laboratory Requirement's Statements of Work for inorganic analysis; all analytical methods, contract required detection limits, contract required quantitation limits, and precision and accuracy requirements shall be as specified therein without modification (DOE/RL 1993d).

d/ NTU = nephelometric turbidity unit(s).

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Table 3-3. Data Quality Objectives for 216-B-5 Reverse Well IRM Plume Pilot-Scale Treatment Testing. (Sheet 1 of 4)

Activity — Pilot-scale Treatability Test

Objectives — Assess effectiveness, operating parameters, and costs of using ion exchange to remove ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ from extracted groundwater.

Prioritized Data Uses

Priority data uses are to support the selection of a preferred interim action alternative for the 216-B-5 Reverse Well IRM plume.

Appropriate Analytical Level or Implementation Guidelines

Level I and II screening analyses will be used for process monitoring. As a minimum, ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and nitrate concentrations will be verified by limited Level III or V analyses. No validation (Level IV) data will be required since only interim action decisions are being supported. Requirements will be refined in the sampling and analysis plan and the quality assurance project plan.

Parameters to be Obtained

Effectiveness:

- Influent and effluent concentrations of ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and nitrate.

Operating Parameters:

- Process chemistry (e.g., total suspended solids, dissolved oxygen, sodium chloride, sulfate, heavy metals, organics)
- Flow rate
- pH, temperature, turbidity, oxidation/reduction potential
- Operating pressures, both differential and point
- Chemical additive requirements.

Resource Needs:

- Equipment/materials
- Personnel and maintenance requirements
- Secondary waste volumes and characteristics
- Power and chemical usages
- Onstream factor
- Health and safety requirements, including field radiation monitoring
- Other cost elements (e.g., mobilization, sample transport, analytical services, decontamination, residuals transport/treatment/disposal).

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Table 3-3. Data Quality Objectives for 216-B-5 Reverse Well IRM Plume Pilot-Scale Treatment Testing. (Sheet 2 of 4)

Required Detection or Measurement Limits

- Effectiveness

Analytical detection limits for ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and nitrate must be able to detect expected effluent concentrations after 90% removal. Accuracy should be sufficient to support calculation of removal efficiency to ±1%. Other supporting documentation such as equipment data sheets may also affect final DQOs. Detection limits will be finalized and other PARCC parameters will be specified in the quality assurance project plan being developed for the treatability test. The following are DQOs for Level III analyses:

Parameter	Method	CRDL/CROL[a/]	Precision	Accuracy
^{90}Sr	EPA 905.0	Variable	±20%	75-125%
^{137}Cs	EPA 901.0	Variable	±20%	75-125%
$^{239/240}Pu$	SW-846 9310	15 pCi/L	±20%	75-125%
Nitrate	EPA 300. 352.1, 353.3, 353.2, 354.1	100 µg/L	±20%	75-125%

- Operating Parameters

Process chemistry will be measured primarily to detect significant and/or unanticipated secondary impacts on system operation and efficiency. Analytical protocols will follow established vendor standards, industrial standards, or EPA practices. Other operating parameters will be measured as follows:

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Table 3-3. Data Quality Objectives for 216-B-5 Reverse Well IRM Plume Pilot-Scale Treatment Testing. (Sheet 3 of 4)

Parameter	Instrument	Range	Accuracy
Flow rate	meter	10-60 gpm	±1 gpm
pH	probe	0-14	±0.1
Oxidation/reduction potential	probe	100-1400 mV	±0.1
Temperature	thermocouple or thermometer	0-100 °C	±1 °C
Turbidity	meter	0-100 NTU[b/]	±5 NTU
Differential pressure	transmitter or gauge	0-30 lb/in^2	±0.5 lb/in^2
Point pressure	transmitter or gauge	0-100 lb/in^2	±1 lb/in^2

- Resource Needs

  Resources will be monitored in accordance with normal recordkeeping practices (e.g., inventory, manhours) specific to each resource type. EPA guidance calls for an accuracy of +50% to -30% in estimating implementation costs.

Critical Samples or Values

- Strontium-90, ^{137}Cs, and $^{239/240}Pu$ concentrations in influent and effluent streams at a frequency proportional to the rate of change in the primary contaminants
- Chemical and radiological concentrations in spent resins and discarded filter cartridges
- Operating costs (e.g., materials, personnel)
- Secondary waste disposal costs.

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Table 3-3. Data Quality Objectives for 216-B-5 Reverse Well IRM Plume Pilot-Scale Treatment Testing. (Sheet 4 of 4)

Constraints
• It is necessary that resin breakthrough be measured in a timely manner for ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$.
• Representative samples are required of process water streams, discarded filter cartridges, and spent resin.
• Groundwater monitoring is required to verify that extracted water is representative of site conditions.
• Some resin and filter cartridge samples may have high radionuclide content and may require special sampling and handling methods.

a/ CRDL = contract required detection limit
CRQL = contract required quantitation limit

b/ NTU = nephelometric turbidity unit(s).

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Table 3-4. Data Quality Objectives for 216-B-5 Reverse Well IRM Plume Contaminant Extraction Testing. (Sheet 1 of 2)

Activity	Pilot-scale contaminant extraction testing.
Objectives	Develop a pumping schedule in terms of time pumping is on, time pumping is off for re-equilibration of partitioning of primary contaminants, pumping locations, and return locations. Estimate total (dissolved and adsorbed) contaminant mass which can interact with groundwater to reestablish a plume after completion of interim action. Develop estimate of primary contaminants.
Prioritized Data Uses	Determine contaminant recovery effectiveness and system efficiency of pump and treat alternative. Develop numerical model of aquifer and primary contaminant response to pumping.
Appropriate Analytical Level or Implementation Guidelines	Level I and II screening analyses (gross alpha, beta, or spectral gamma radiation) will be used for preliminary determination of pumping schedule, to be confirmed by limited Level III and Level V analyses for specific radionuclides.
Parameters to be Obtained	• <u>Effectiveness</u> - Concentrations of ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and nitrates in extracted groundwater - Pumping rates and locations, times for pumpage on and off - Estimates of adsorbed and dissolved ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ in aquifer and on aquifer materials.

Table 3-4. Data Quality Objectives for 216-B-5 Reverse Well IRM Plume Contaminant Extraction Testing. (Sheet 2 of 2)

Parameters to be Obtained (cont.)

- Parameters for System Optimization
  - Aquifer hydraulic properties and contaminant distribution properties
  - Estimates of total primary contaminant quantities
  - Optimized pumpage cycling (in regard to pumping rates, aquifer re-equilibration times, and moving pumping among available wells) to maximize recovery.
  - Computer model input parameters for local groundwater flow and contaminant phase transformation and transport.

- Resource Requirements
  - Electrical costs of pumping
  - Installation of additional wells
  - Technical personnel time to interpret process effectiveness
  - Analytical costs
  - Other significant cost contributors

Required Detection or Measurement Limits

Parameters for field or mobile laboratory screening methods will be developed in the test sampling and analysis plan (Section 5.0). Parameters for all analytical measurements will be based on usual limits of normal analytical services as expressed in Table 3-3 and the quality assurance project plan (Section 5.0). Screening methods are used due to the need for fast turnaround time to interpret analytical data. Costs will be monitored in accordance with normal recordkeeping practices. Estimates of total (adsorbed and dissolved) primary contaminant mass in aquifer matrix and groundwater will be made through a calibrated computer model, and are likely to be accurate to about a half an order of magnitude.

Critical Samples or Values

Primary contaminant concentrations during pumpage and after re-equilibration.

Constraints Timing of extraction testing, pumping rates, and pumping procedures cannot be estimated beyond first cycle. Remainder of extraction testing will depend on observed response of groundwater system during initial testing.

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4.0 TREATABILITY TEST DESIGN AND OPERATING REQUIREMENTS

This section describes design and operating requirements for the 200-BP-5 Operable Unit pilot-scale treatability test. The activities described in this section are designed to fulfill test performance objectives and DQOs discussed in Section 3.0. Individual subsections discuss groundwater withdrawal and return well selection (Section 4.1), contaminant extraction test design and operation at the 216-B-5 Reverse Well IRM plume (Section 4.2), treatment test activities (Section 4.3), and treatability test health and safety (Section 4.4). Supporting documentation requirements and the project schedule are discussed in Sections 5.0 and 7.0, respectively.

4.1 TEST WELL SELECTION

Satisfactory pilot-scale treatability testing requires that contaminated groundwater be provided to the treatment system at the design flow rates for the expected duration of testing. The treated water must also be returned to the subsurface at an equivalent rate and at locations that do not adversely affect the ability of the treatability test to achieve the test performance objectives. Well evaluation and selection is, therefore, determined by the intended use of the well, its location with respect to the plume, and the combined well/pump/aquifer properties.

Continuous pumping rates for both IRM plume treatability test systems are expected to be 10 to 20 gal/min. Treated water will typically require greater well specific capacity due to the inherent resistance of the aquifer to reabsorb returned water. Design specifications may restrict the maximum pumping distance from the treatment test system.

Candidate wells for both IRM plumes have been evaluated for several factors to optimize both the pump and treat aspects of the test design. The criteria used for the evaluation included the following:

- Access to the highest concentrations of ^{60}Co and ^{99}Tc at the 216-BY Cribs IRM plume (^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ at the 216-B-5 Reverse Well IRM plume)
- Well construction and aquifer characteristics suitable for test operations
- Proximity of withdrawal wells to return wells to avoid recirculating groundwater without adversely affecting the ability to meet test performance objectives effecting contaminant removal.

Well inspections and drawdown tests will be necessary to better characterize the capabilities of the well/aquifer system for both withdrawal and return purposes. The inspections will view well casings with a television camera, and necessary remediation will be performed prior to the 8-hour drawdown pump test. Water samples will be taken at intervals during the pump test and analyzed for primary contaminants. This data will support numerical

modeling groundwater flow and contaminant migration over time. The schedule for this work is presented in Section 7.0. The following sections discuss the candidate wells and site conditions pertinent to these criteria.

4.1.1 216-BY Cribs IRM Plume Test Wells

Well construction data and groundwater levels are reported in Table 4-1 for 16 wells penetrating the unconfined aquifer north of the 200 East Area. The wells are spread across an area of approximately 4.5 mi^2 within the northern half of the 200-BP-5 Operable Unit and well spacings usually exceed 2,000 ft. Since, based on available data, there is no instance where wells are close enough to pair up for withdrawal and recirculation, construction of new wells may be required.

As shown in Figure 1-3, there are only a few monitoring wells within the 216-BY Cribs IRM plume. The list of primary contaminant concentrations for each well within the plume (Table 1-1) indicates that Well 699-50-53A has the highest aggregate concentration of primary contaminants, followed by Wells 699-49-55A, 699-49-57A and 699-52-54. Most wells within the 216-BY Cribs IRM plume boundaries have been inspected and remediated within the last 3 years. There are no records of aquifer tests during well completion or recent well remediation.

Table 4-1 reports aquifer thickness data at the candidate wells based on water level monitoring from June and September 1993. Well 699-52-54 has dried up and Well 699-50-53A has less than a 1.0 ft thickness of saturated sediments. Further to the south and west, the aquifer thickens to about 9 ft at both Well 299-E33-7 and 699-49-57A and to 10 ft at Well 699-49-55A.

Based on the above information, Well 699-49-55A is the preferred well for groundwater withdrawal. Despite lower concentrations for the primary contaminants than exists at Well 699-50-53A, the greater thickness of saturated sediment increases the chances for satisfactory long-term treatability testing when compared to Well 699-50-53A. Well 699-49-57A is considered to be a backup site. Well 299-E33-7 is not recommended as a treatment test site due to its proximity to the 200-BP-1 Operable Unit and upcoming barrier test projects. Construction data indicates that Well 699-49-55A is constructed with a 15-ft length of 6-in. diameter, 0.03-in. slot size, telescoped screening, installed at the top of basalt.

The nearest significant groundwater contamination is a ^{90}Sr plume associated with the stabilized 216-A-25 Gable Mountain pond site located approximately 4,000 ft to the northeast, on the north side of the basalt high. It is expected to be unaffected by the low pumping rates from the 216-BY Cribs IRM plume treatability test.

Several options to remediate candidate wells can be considered. Wells can be deepened 5 to 10 ft into the basalt to provide a sump for pumping. Alternately, the present wells may be used as recirculation points for new extraction wells drilled into potentially thicker zones of the aquifer. New wells also offer a chance to more clearly define the extent of the plume.

4.1.2 216-B-5 Reverse Well IRM Plume Test Wells

Access to the contaminant plume is an important factor for the success of treatability testing at the 216-B-5 Reverse Well IRM plume. Table 4-2 lists 12 wells evaluated for withdrawal or return at and around the 216-B-5 Reverse Well IRM plume site, four of which are candidates for groundwater pumping. Three wells drilled by Smith (1980), 299-E-28-23, -24, and -25, (Figure 1-4), are located within a 20 ft radius of the 216-B-5 Reverse Well and lie within a surface radiation zone. Another well, 299-E28-7, is located along the same northwest-southeast line 65 ft southeast of the 216-B-5 Reverse Well. The first three wells provide the best access to the IRM plume contaminants and are considered, along with the 216-B-5 Reverse Well itself, as the best sites for groundwater withdrawal.

Potential recirculation wells lying within a 400 to 500 ft radius of the reverse well site are Wells 299-E28-1, -2, -3, and -10. Wells 299-E28-2, 299-E28-3, and 299-E28-10 are located west of Baltimore Avenue and would require a protected pipe crossing under the street. The wells are 8 in. in diameter and are perforated over a 10 to 40 ft length of casing just above the top of basalt.

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As discussed in Section 1.3.2, Well 299-E28-23 has the highest observed concentrations of primary contaminants, followed by Well 299-E28-25, -24, and -7. Concentrations of the primary contaminants are not known at the 216-B-5 Reverse Well but are expected to equal or exceed the range of values in Table 1-1.

Wells 299-E28-23, -24 and -25 were drilled by the same program and were constructed to the same specifications: 4-in. diameter, 0.01-in. slot size, stainless steel well screen in the bottom 50 ft of each well, placed at or just above the top of the basalt. Well 299-E28-7 is 6-in. diameter casing perforated over its bottom-most 65 ft. The 216-B-5 Reverse Well is constructed of 8-in. diameter casing, perforated over the bottom-most 50 ft. None of the five wells have not been inspected or remediated since completion.

The high transmissivity values (Section 1.3.2), coupled with an aquifer thickness in excess of 45 ft, provides reasonable assurance of supplying the test system with sufficient quantities of groundwater from any well near the 216-B-5 Reverse Well IRM plume.

Well 299-E28-23 is the preferred site for extraction from the standpoint of access to primary contaminants. Wells 299-E28-24 or -25 are second choices due to their proximity to both the zones of groundwater and soil contamination. The 216-B-5 Reverse Well may be an equally suitable alternate but further evaluation is necessary. Well 299-E28-1 is the preferred groundwater return site for the test system as it is the only well located upgradient from the 216-B-5 Reverse Well IRM plume and has been retrofitted with telescoping well screening.

4.2 CONTAMINANT EXTRACTION TEST

It is not anticipated that there will be difficulties in extracting contaminants from the 216-BY Cribs IRM plume (as described in the conceptual

model in Section 1.3.1); however, operational monitoring procedures for the pilot-scale pump and treat system will be used to verify contaminant extraction effectiveness. The contaminant extraction testing described below is designed to test the ability of groundwater pumping to effectively extract ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ from the 216-B-5 Reverse Well IRM plume. The conceptual model describing contaminant distribution is presented in Section 1.3.2. Test performance objectives and DQOs are discussed in Sections 3.1.2 and 3.2.2, respectively. Extraction effectiveness testing will be carried out, if possible, as part of initial operational testing of the pilot-scale pump and treat system for the 216-B-5 Reverse Well IRM plume.

Test-specific equipment needs, final test design and test operating procedures will be specified in follow on Description of Work level documents. These documents will be developed prior to initiation of testing and will include test equipment design specifications, test operating procedures, and a test sampling and analysis plan and quality assurance project plan. These documents are described in Section 5.0 of this treatability test plan.

4.2.1 Contaminant Extraction Test Design

The 216-B-5 Reverse Well IRM plume contaminant extraction test is designed to determine the ability to extract primary contaminants from the aquifer (and consequently be treated by the pilot-scale treatment system). This will be accomplished by pumping groundwater from the well (or wells) in which the highest primary contaminant concentrations have been detected, monitoring indicator parameters, and when indicator parameters have been reduced to a pre-determined level or are not showing further reduction, ceasing pumping and allowing sorbed contaminants still in the saturated zone to re-equilibrate with groundwater. Initial data will be used to refine a plume model and optimize follow-on test pump cycles. Wells in the 216-B-5 Reverse Well IRM plume (as described in Section 4.1) are expected to provide sufficient groundwater production (which will be confirmed by well production testing prior to initiation of pilot-scale treatment) and a representative sample of groundwater from the uppermost unconfined aquifer. Table 4-2 gives construction data for wells in the vicinity of the test site. Final well selection will take place following well production tests and will be specified in test procedures developed in follow-on documents. Results of this contaminant extraction test will be used to refine well design for full-scale pump and treat systems in the 216-B-5 Reverse Well IRM plume.

4.2.2 Contaminant Extraction Test Operation

Groundwater will be extracted from Well 299-E28-23 (the well in the vicinity of the test site with highest observed primary contaminant concentrations) at a rate of 10 to 20 gal/min. For the first test cycle, the pumping rate will be consistent with the anticipated design treatment capacity of the pilot-scale treatment system. Pumping rates in subsequent test cycles may be increased to test the ability to extract primary contaminants more rapidly and to assess the effect of increased groundwater withdrawal flow rates on contaminant concentrations. According to the conceptual model (Section 1.3.2), primary contaminant concentrations are expected to decrease

rapidly. After pumping ceases, contaminants sorbed to saturated zone soils will re-equilibrate with the surrounding groundwater. During this period, primary contaminant indicator parameters are expected to rise to or nearly to the original levels. Data collected during this first cycle will be used to generate a numerical model of both aquifer and contaminant response to pumping. This model will be used to refine follow-on testing cycles and optimize primary contaminant extraction rates.

4.2.3 Contaminant Extraction Test Monitoring

Water levels in the pumping well and surrounding wells (to be identified in test procedures) will be monitored continuously. Monitoring of water levels will allow this extraction effectiveness test to also serve as an aquifer pump test and further refine the conceptual model of aquifer parameters.

During pumping, groundwater withdrawn from Well 299-E28-23 will be monitored continuously for gross alpha, gross beta, and spectral gamma characteristics. These will serve as indicator parameters for primary contaminants, (i.e., gross beta for ^{90}Sr, gross alpha for $^{239/240}Pu$). Indicator parameters are used rather than primary contaminant concentrations for speed of sample turn around. Confirmatory analyses will be used to monitor primary contaminant levels during the test.

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Samples will be collected from surrounding wells at the start of the test and at 2-hour intervals during the test, and field monitored for gross alpha, gross beta, and spectral gamma characteristics. Additional samples will be taken at the beginning of the test, at 1-hour intervals for the first 24 hours, and at 6-hour intervals subsequently for confirmatory laboratory analysis (Level III or Level V). Samples may be returned to the pilot-scale treatment system after analysis for subsequent treatment by the system. Treated water will be returned to the aquifer via the aquifer return well selected for the pilot-scale pump and treat system.

Groundwater will be pumped from the aquifer until primary contaminant indicator parameters have reached a pre-determined concentration or are no longer being reduced. Specific reduction targets will be specified prior to imitation of testing. For example, the initial pumping cycle may be run until the indicator parameters are reduced to a degree proportional to the concentration of primary constituents over drinking water standards. This would approximate extraction requirements necessary for full-scale pump and treat system. In this example, the current concentration of ^{90}Sr in Well 299-E28-23 is approximately 600 times the drinking water standard (Appendix A), therefore, the extraction efficiency test would continue until gross beta levels in this well are reduced from approximately 12,000 pCi/L (average gross beta as presented in Appendix A) to 19 pCi/L in the pumped groundwater. Subsequent indicator parameter targets will be set based on initial groundwater sampling and first cycle test results.

When indicator parameter target levels are reached, pumping will be discontinued at Well 299-E28-23. Samples will be taken at 6-hour intervals from the pumped well and surrounding groundwater wells and field screened for

gross alpha, gross beta, and spectral gamma characteristics. Additional samples will be taken at cessation of pumping, at 6-hour intervals or the first 24 hours, and at 12-hour intervals subsequently for confirmatory laboratory analysis (Level III or Level V). The wells will be monitored initially for a time period equal to the duration of the pump test or until primary contaminant indicator parameters have returned to original levels. Initial data will be evaluated at the end of that time and the need for additional monitoring determined. At a point to be determined, the pumping well will be changed to establish primary contaminant response at another location.

Extraction effectiveness test results will be used to determine the effect of the following variables on primary contaminant equilibria in the aquifer:

- duration of pumping
- rate of pumping
- duration of re-equilibration period
- location of pumping
- cumulative effects of pumping (hysteresis)
- location of recharge.

Test data will be used to develop a three dimensional numerical model of plume aquifer response and contaminant adsorption/desorbtion rates as affected by groundwater withdrawal. This model will be calibrated using initial test data, and used to develop follow-on test parameters and optimize primary contaminant extraction. Follow-on data will subsequently be used to revise the model and further optimize contaminant extraction.

4.3 TREATMENT TEST

4.3.1 Laboratory Treatability Testing

Laboratory treatability tests will be completed to provide information for the evaluation and selection of one or more ion exchange resins effective in removing the primary contaminants ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, and $^{239/240}Pu$. The laboratory tests will also assess resin performance for the removal of secondary contaminants, including cyanide and nitrate. The selected or preferred resin(s) must have a high affinity for removing primary contaminants from the groundwater over the anticipated pH range, should demonstrate rapid adsorption of the primary contaminants, and not impose a high pressure drop due to small particle size in a column flow operation. A resin or combination of resins will be selected for each of the two IRM plumes based on the results of these tests. The laboratory treatability testing will be performed according to procedures developed by the chemist to fit the contaminant levels and type of resin available. The specific laboratory test procedures will be included in the sampling and analysis plan and quality assurance project plan as described in Section 5.0.

Samples of groundwater from the two 200-BP-5 Operable Unit IRM plumes will be furnished for conducting these tests. Testing will include the following:

- Equilibrium Distribution Measurements - Contact appropriate volumetric samples of preconditioned groundwater (filtered and analyzed for ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, or ^{60}Co and ^{99}Tc, and secondary contaminants, including cyanide and nitrates) that have been adjusted to specific pH values in the range of 5 to 8 with known amounts of resin(s) to perform batch equilibriums. The batch equilibriums should be performed in duplicate or triplicate over 24-hour periods. Afterwards, the samples will be centrifuged or filtered as appropriate, and the solution will be analyzed for "post-contact" ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ (or ^{60}Co, ^{99}Tc, and cyanide) along with nitrate concentrations. The distribution coefficients will then be calculated using these results.

- Flow-Through Column Measurements - Once the equilibrium measurements have screened candidate resins to determine a preferred resin(s), small-scale column tests will be performed using known amounts of resin in a small 2- to 3-cm diameter column. Groundwater will be passed through separate columns at various flow rates in an effort to determine the kinetics (i.e., rates of adsorption) for the particular resin(s). The kinetics will be determined by comparing the influent concentrations (C_o) with the effluent concentrations (C) over time for contaminants.

A minimum of one duplicate sample analysis will be performed for every twenty samples analyzed.

4.3.2 Pilot-Scale Treatability Test Design

4.3.2.1 Treatment Process Description. A conceptual process flow diagram representative of the two 200-BP-5 Operable Unit pilot-scale treatment systems is shown in Figure 4-1. Note that the optional cyanide destruction unit will only apply to the 216-BY Cribs IRM plume treatment system. Each treatment system will be run continuously each operating day for approximately 6 hours, at the following design flow rates:

- 216-BY Cribs IRM plume; 30 to 100 gal/min, depending on pump rate tests

- 216-B-5 Reverse Well IRM plume; 50 gal/min.

For each treatment system, groundwater will be withdrawn from a well and pumped to an influent storage tank. Since the existing withdrawal wells are expected to produce no more than 20 gal/min, the influent storage tank decouples the groundwater withdrawal operation from the treatment process. The withdrawal well pump will operate continuously to fill the storage tank, thereby providing sufficient volume of groundwater for the treatment system to operate at the design flow rate. Groundwater will be pumped from the storage tank through particulate filters for removal of suspended solids, then through

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the ion exchange system for removal of ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ (or ^{60}Co and ^{99}Tc) and finally to an effluent storage tank. The effluent storage tank will be used to transfer the treated groundwater to the aquifer return well at rates similar to the withdrawal well on a continuous basis. In addition, if it is determined that the treated effluent does not meet test objectives (i.e., 90% removal of primary contaminants), the groundwater can be returned for additional treatment.

A filtration unit will be incorporated as a pretreatment technology to remove suspended solids contained in the groundwater before it enters the leading ion exchange bed. This pretreatment will minimize the potential for any inert and/or biologically active suspended solids to accumulate on the resin surface, masking the exchange sites, and resulting in loss of exchange efficiency. It will also minimize the potential for solids to plug the void spaces among the beads of resin and restrict flow through the bed. Furthermore, because many of the constiuents in Hanford Site groundwater have an affinity for the soil, there is the potential for removing contamination associated with the inert, suspended solids.

The filtration units will use pressure generated by the system pump(s) to drive groundwater through cartridges containing a membrane matrix with extremely fine pores that will trap particulates. Trapped particulates will be removed from the treatment system by periodic replacement of dirty filter cartridges with clean ones. Dirty cartridges will be dried and then packaged appropriately for disposal as secondary waste.

Ion exchange is a technology that removes ions from solution by adsorption on a solid media (i.e., resin). When groundwater flows through an ion exchange column, ionic species in groundwater exchange with ions on the media until equilibrium is attained or a predetermined percent breakthrough of a primary contaminant is achieved. Ion exchange resins have a finite adsorption capacity based on available exchange sites on the resin. Cobalt-60, ^{90}Sr, ^{99}Tc, ^{137}Cs, and $^{230/240}Pu$ may compete with other ions found in groundwater for these exchange sites. The ion exchange resins that will be used for this treatability study will be selected for their ability to selectively adsorb the primary contaminants. However, because the radionuclide concentrations are several orders of magnitude below those of the major ionic species (e.g., nitrates and sulfates), compounds other than the primary contaminants may determine resin exhaustion rates. When the resin is "spent" (exceeds its adsorption capacity), breakthrough or detection of primary contaminants in the column effluent will occur. At that point, the spent resin will require replacement. During the treatability test, spent resin will be replaced rather than regenerated to eliminate the volume of aqueous secondary wastes that would result from a regeneration cycle.

The 216-BY Cribs IRM plume treatment system will consist of an ion exchange treatment system (Figure 4-1) that includes two downflow, pressurized ion exchange columns operated in series. Effluent from the leading ion exchange bed will be monitored for breakthrough. Consistent effluent quality will be ensured by passing the effluent from the leading ion exchange bed through the downstream (lagging) polishing bed. When breakthrough is reached, the flow of groundwater will be diverted to a third, spare column containing fresh ion exchange resin. The column containing the spent ion exchange resin

will be valved out of the process train so that the spent resin can be removed and replaced with fresh resin. The flow configuration will be revised by opening and closing valves so that the previous lagging bed will serve as the leading bed and the spare, fresh bed will become the lagging bed.

Experience indicates that the pH of the aqueous stream can affect selectivity of a given ion exchange resin for a given targeted ion. Thus, a pH adjustment system will be included as a pretreatment process in the treatment system to support optimization of groundwater pH. The pH adjustment system will include means for adding sodium hydroxide to increase pH (or hydrochloric acid to reduce it) before the groundwater enters the ion exchange vessels and to neutralize the pH before the treated water is returned to the aquifer.

The conceptual process flow diagram for the 216-BY Cribs IRM plume shown in Figure 4-1 includes the cyanide destruction treatment process (that may be required). If implemented, the destruction of cyanide via alkaline chlorination to nitrogen (possibly as ammonia) and carbon dioxide is a three-step process, as shown in Figure 4-1. In the first step, oxidation of the cyanide to cyanate will be performed by adding sufficient sodium hydroxide to raise the groundwater pH to approximately 11 and adding sodium hypochlorite. In the second step, the cyanate will be converted to carbon dioxide and nitrogen by acid hydrolysis which will require adding sufficient hydrochloric acid to reduce the pH to approximately 3. The treated water will then be neutralized by the addition of sodium hydroxide prior to discharge to the ion exchange beds. Each of the steps is conducted in a separate tank with gravity flow between tanks. A transfer tank at the end of the cyanide destruction process is used to pump the groundwater to the ion exchange system. If ammonia results from cyanide destruction, it will exist as ammonium ions, which may compete with ^{60}Co and/or ^{99}Tc in the ion exchange process, thus possibly reducing the exchange capacity of the ion exchange resin.

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If it is incorporated in the treatment system, the cyanide destruction unit will have several parameters that can be modified to achieve the desired cyanide removal or to increase the cyanide removal effectiveness. For example, it will be possible to vary the flow rate through the unit (subject to matching the flow rate through the ion exchange system), the pH at which oxidation of cyanide to cyanate occurs, the sodium hypochlorite dosage, and the pH at which the subsequent acid hydrolysis of cyanate to carbon dioxide and nitrogen occurs. It is anticipated that these parameters will be varied throughout the duration of the test to identify and then maintain the optimal conditions for these reactions.

A second filtration unit will be incorporated downstream of the ion exchange vessels to remove any suspended solids that may be formed by biological activity in the system, oxidation of dissolved species by exposure to the atmosphere, and/or by the addition of chemical for pH adjustment or cyanide destruction. For example, adding sodium hypochlorite may result in oxidation of any dissolved ferrous iron or manganous manganese to form insoluble precipitates. This downstream filtration will minimize any potential for plugging the return wells.

Groundwater will be withdrawn from the selected wells using submersible pumps. The pumps will convey groundwater to an influent storage tank within 25 ft of the treatment plant location. The groundwater pumps will operate automatically to fill the storage tank on an as needed basis. The groundwater extraction system will operate independently of the treatment system and may have to operate continuously if the treatment flow rate exceeds the capacity of the withdrawal well. Controls will be installed in the influent storage tank to start and stop the withdrawal pump based on the tank level.

Treated groundwater will be stored in an effluent storage tank prior to return to the aquifer. The treated water will be pumped from the storage tank to the return well. The pump will be automatically controlled using level controls in the effluent tank. The groundwater return system will operate independently from the treatment system and may be required to operate continuously if the treatment flow rate exceeds the capacity of the return well.

The ion exchange treatment process for removing ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$ from groundwater extracted from the 216-B-5 Reverse Well IRM plume will be configured essentially the same as the process for treating groundwater from the 216-B-Y Cribs IRM plume. Specifically, the treatment system will include the basic ion exchange unit as well as the pH adjustment and filtration pretreatment steps described above. However, depending on the result of laboratory tests, different ion exchange resin(s) may be used to provide enhanced selectivity for ^{90}Sr, ^{137}Cs, and $^{239/240}Pu$. Also, it is not anticipated that any pretreatment will be required beyond the pH adjustment, neutralization, and filtration steps. Since no ionic complexing is evident for primary contaminants in the 216-B-5 Reverse Well IRM plume, pretreament to break chemical complexes (such as cyanide destruction) is not anticipated.

4.3.2.2 Pilot-Plant Treatment Equipment. Treatment plant equipment will be mounted on skids to enable transportation by flat bed truck to the proposed test sites. Individual skids will be constructed for each of the proposed ion exchange systems, and the cyanide destruction system, if used.

For each of the two sites, influent groundwater will be filtered for suspended solids removal using cartridge filters prior to the ion exchange system. The feed pumps to the system will be interlocked with levels in the influent and effluent tanks to prevent tank overflow and protect the pumps. A flow indicating totalizer will be used to monitor the processing flow rate to the plant. Cartridge filters will be used to filter the effluent to remove any suspended solids formed in the process.

The ion exchange system(s) will be piped to allow for series or parallel flow. Each ion exchange column will be sized for a minimum empty bed contact time of 8 minutes. Differential pressure indicators will be installed to measure the pressure drop across each ion exchange column.

If pH adjustment of the ion exchange feed is required, then a neutralization system will also be required to adjust the pH of the treated effluent back to neutral before discharge to the effluent storage tank. The pH adjustment and neutralization systems would consist of chemical storage

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tanks for acid and base solutions and chemical metering systems for both the acid and base adjustments controlled by pH controllers.

At the 216-BY Cribs IRM plume, cyanide destruction may be necessary to attain the ^{60}Co removal requirements. If required, the cyanide destruction system will consist of chemical storage tanks, process tanks, a transfer tank, and a transfer pumping system. For cyanide destruction, the chemical storage tanks will contain oxidizing agents (e.g., sodium hypochlorite), hydrochloric acid, and sodium hydroxide. The pH and oxidation/reduction potential controllers in the process tanks will automatically adjust metering pumps to control chemical addition rates. The process tanks will be equipped with an agitator. The volume of each of the process tanks will be specified to provide adequate residence time to complete the pH adjustments and the alkaline chlorination and hydrolysis reactions.

4.3.2.3 Groundwater Withdrawal and Return. Since the existing wells are somewhat limited in number and flow rate, and since the pilot-scale treatment system has an operating rate more than the expected well withdrawal rate (20 to 50 gal/min treatment rate versus <20 gal/min withdrawal rate), the strategy for withdrawing groundwater for treatment and return to the aquifer dictates that the wells be decoupled from the treatment system with the use of surge storage tanks. Groundwater will be withdrawn on a continuous basis, filling a large (up to approximately 20,000 gal) storage tank; the treatment system will be operated on the day shift under engineering support (approximately 6 hours to process approximately 18,000 gal); the treated effluent will be transferred to an effluent storage tank and returned to the aquifer at approximately the same rate as for withdrawal. Level controls will be interlocked with the well pumps to prevent overflowing the storage tanks.

Prior to returning the treated water to the aquifer, it will be filtered to remove any solids that may occur from biological activity in the effluent storage tank. In addition, the system will include the ability to add sodium sulfite to the aquifer return flow at the well head to scavenge dissolved oxygen, but only if this is determined to be necessary to mitigate biological activity and prevent possible plugging of the return well.

4.3.2.4 Support Components. The skid mounted treatment plant equipment will be placed within a frame-supported fabric structure to provide protection from the weather. The interior of the structure will be heated by propane heaters to avoid the need to winterize all plant components. Some process components may be heat traced and insulated for freeze protection.

The proposed test site locations are not currently served by utilities. Portable generators, fuel tanks, air compressors, lighting, and toilets must be provided at each test site. A potable water tank will be used at the site for personnel decontamination, chemical makeup water, and slurrying resin in and out of the ion exchange columns. Bottled drinking water will be provided at the site in an office/laboratory trailer. Portable eyewashes and showers will also be placed at each test site.

Small leaks and drips may occur during system operation due to equipment changeout, hose and pipe connect and disconnect, and related activities. All

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leakage and drippage will be contained and returned to the treatment system or to the influent storage tank.

4.3.3 Pilot-Scale Treatability Test Operation

4.3.3.1 Pilot-Scale Fabrication and Set-Up. The skid-mounted treatment plants and equipment will be fabricated in Hanford Site shops or will be procured directly from vendors. At the completion of the detailed design, the procurement of treatment plant components will be initiated. System components will be selected and/or shop fabricated to be in conformance with relevant Occupational Safety and Health Administration and National Electrical Code standards to minimize the need for modifications in the field. Components will be mounted on skids to allow for easy transportation to the test site and to minimize test site preparation requirements. Prior to transportation to the test sites, acceptance tests will be performed on the system. Acceptance test procedures will be prepared in accordance with WHC *Standard Engineering Practices* (WHC-CM-6-1, Appendix M, WHC 1988a).

Prior to startup of the plants, a readiness review will be performed using the process described in Environmental Investigation Instruction (EII) 1.13, *Environmental Readiness Review* (WHC 1988b). Completing the readiness review and other pre-test activities and checklists will lead to the start of the treatability tests, and meet the Tri-Party Agreement Milestone M-13-06A, "Initiate pilot-scale pump and treatment operations for 200-BP-5 Operable Unit 30 days after the Treatability Test Plan is approved but no sooner than August 31, 1994."

4.3.3.2 Operation. The treatability test plan has been developed and the pilot-scale plants designed to allow for modifications in response to test observations and process monitoring results. Modifications may include changes in the operating parameters, plant configuration, or selected resin.

Standard operating procedures will be prepared for the pilot-scale test. The treatment system will be operated for approximately 6 hr/day during the course of the pilot test program. While the treatment system is operating, an operator will remain onsite to monitor the process. Operation of the groundwater extraction and return systems will not be tied directly to that of the treatment system. Groundwater extraction and return will be automated for safety shutdowns and will operate continuously, and without constant operator oversight.

Data on the effectiveness of the treatment process will be collected throughout the test program. If the plant does not achieve the desired treatment levels, operating parameters will be changed or the plant will be modified until treatment is either successful or is determined to be ineffective. The successful demonstration of the treatment system effectiveness implies that primary contaminants continue to be detected in the groundwater influent to the pilot plant.

Full evaluation of the treatability test will require that the ion exchange columns be operated to breakthrough so that an estimate of the adsorption capacities of the ion exchange resin(s) for ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs,

and $^{239/240}Pu$ can be made. The ion exchange systems have been designed to enable changes in operating conditions or to allow for plant modifications. It is initially proposed to operate each treatment system as two ion exchange columns in series with the same type of ion exchange resin in both columns. Under this initial operating configuration the system flow rate (column residence time) is the only operating parameter that can be varied.

The pilot plant piping will allow the system to be operated with up to three columns in series, with two columns in series followed by a third column with a different resin. The plant is designed to enable resin changeout at breakthrough or if the treatment effectiveness of a different resin is to be evaluated.

The ion exchange system is also designed to include a chemical addition system. The chemical addition system can be used to change the pH of the groundwater prior to the ion exchange columns. The pH of the groundwater is a parameter that effects ion exchange adsorption efficiencies. If chemical addition results in a change in pH of treated groundwater, then a neutralization system would be used to readjust the groundwater pH prior to aquifer disposal.

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Based on laboratory findings, the pilot plant for treating the 216-BY Cribs IRM plume may include a cyanide destruction system prior to the ion exchange system, if this is necessary to achieve test performance objectives. The optional cyanide destruction system would be fully automated. The test program would demonstrate the ability of the unit to operate at steady state while consistently achieving the required target radionuclide treatment levels.

The proposed cyanide destruction unit has several parameters which can be modified to achieve cyanide destruction. The flow rate through the system can be varied, but must match the flow rate through the ion exchange system. The pH at which alkaline chlorination of cyanide to cyanate occurs, and the pH at which the subsequent acid hydrolysis of cyanate to carbon dioxide and nitrogen occurs, can be varied throughout the tests to determine the optimal conditions for these reactions. The sodium hypochlorite dosage can also be varied to determine the optimal addition rate. Plant equipment will be specified to allow for a wide range of chemical addition rates.

During the performance of the test, secondary wastes will be generated that will require characterization for disposal. These wastes include filter cartridges and spent resin. Samples of the resin may be evaluated for regeneration, or alternatively may be used to evaluate a resin drying system that would allow the material to be disposed of as a solid waste.

4.3.3.3 Process Waste Management. In accordance with a tentative Tri-Party Agreement change (Change Number M-13-93-03), secondary wastes will be disposed and/or stored onsite at locations agreed to by the three parties. Section 5.0 of this test plan provides for the preparation of a waste control plan for handling and disposition of wastes generated during treatability testing. Ecology is required to approve the waste control plan prior to initiating the pilot-scale test. Laboratory wastes will be disposed of in accordance with existing waste-handling procedures.

Field testing will generate secondary wastes primarily through the replacement of filter cartridges and spent resins. Aqueous wastes will be treated by the pilot plant. All other wastes, will be disposed of per WHC policy for onsite disposal according to waste type (WHC 1988a).

4.3.4 Pilot-Scale Treatability Test Monitoring

A considerable sampling program will be required during the pilot-scale treatability tests. The amount of sampling will be determined by the final treatment system configuration. The monitoring requirements fall into two distinct areas: process monitoring and groundwater monitoring. The DQOs presented in Section 3.2 will be further refined to direct sampling.

4.3.4.1 Process Monitoring. Process monitoring will be performed to control and operate the treatment process and to gather performance data. The effectiveness of the treatment system will be primarily demonstrated through laboratory Level III and V chemical analyses of process samples. Samples from the plant influent and effluent, and the influent and effluent from the lead ion exchange column will be taken. For the two sites ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, and $^{239,240}Pu$ will be the primary contaminants of concern. Additionally, secondary contaminants, such as nitrates and cyanide, will be monitored, but less frequently. Operating parameters such as pH, oxidation/reduction potential, temperature, turbidity, specific conductance, and alkalinity will also be monitored because of their potential impact on the treatment process. The frequency of sampling will be related to the observed rate of change of contaminant concentrations in the untreated groundwater, and the estimated breakthrough times for the ion exchange columns. Section 5.0 of this test plan provides for the preparation of a process sampling and analysis plan and a quality assurance project plan.

In addition to laboratory Level III and V chemical analyses to determine treatment effectiveness, process monitoring will be performed using field screening analysis to provide quick turnaround times. Online monitors will be used whenever possible. Radiation monitors will be used throughout the test to refine operational procedures and specify personnel protective equipment.

Pressure drops across ion exchange beds will be monitored throughout the tests to assess the buildup of suspended solids on the resin and the need for backwashing. Solids generation and accumulation in different parts of the plant will be documented. An accounting of all secondary waste generation will be made. Maintenance during operation of the pilot plant will be documented. Chemical addition rates and volumes will also be documented. The volume of groundwater pumped to the treatment train and returned into the aquifer will be measured with flowmeters.

4.3.4.2 Groundwater Monitoring. Field activities will be conducted to monitor impacts of the pilot-scale test to the local upper unconfined aquifer. Monitoring activities include water table level measurements and groundwater sampling for chemical analyses.

In addition to requirements identified in the test sampling and analysis plan, all work will be performed in accordance with the following applicable documents and procedures:

- WHC-EP-0383, *Environmental Engineering, Technology, and Permitting Function Quality Assurance Program Plan* (WHC 1990)

- WHC-CM-7-7, *Environmental Investigations and Site Characterization Manual* (WHC 1988b)

  - EII 1.5 Field Logbooks
  - EII 5.1 Chain of Custody
  - EII 5.4 Field Cleaning and/or Decontamination of Equipment
  - EII 5.8 Sample Packaging and Shipping
  - EII 10.3 Purgewater Management

- WHC-CM-7-8, Volume 4, *Environmental Engineering and Geotechnology Function Procedures* (WHC 1992)

  - Section 2 2, "Groundwater Quality Control Sampling"

  - Section 2.5, "Temperature Control of Groundwater Sample Storage Refrigerators"

  - Section 5.2, "Groundwater Measuring and Test Equipment (M&TE) Calibration by User"

  - Section 5.2, "Groundwater M&TE Calibration by WHC Standards Laboratory."

4.4 HEALTH AND SAFETY

All field personnel working to this treatability test plan will have completed the 40-Hour Hazardous Waste Site Worker Training Program and will perform all work in accordance with the following:

- WHC-CM-1-6, Westinghouse *Radiological Control Manual* (WHC 1993)
- WHC-IP-0718, *Health Physics Practices Manual* (WHC 1988c)
- WHC-CM-4-3, *Industrial Safety Manual* (WHC 1987)
- WHC-CM-7-5, *Environmental Compliance Manual* (WHC 1988d)
- Applicable safety documentation.

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Figure 4-1. Conceptual Process Flow Diagram for the 200-BP-5 Operable Unit Treatability Test.

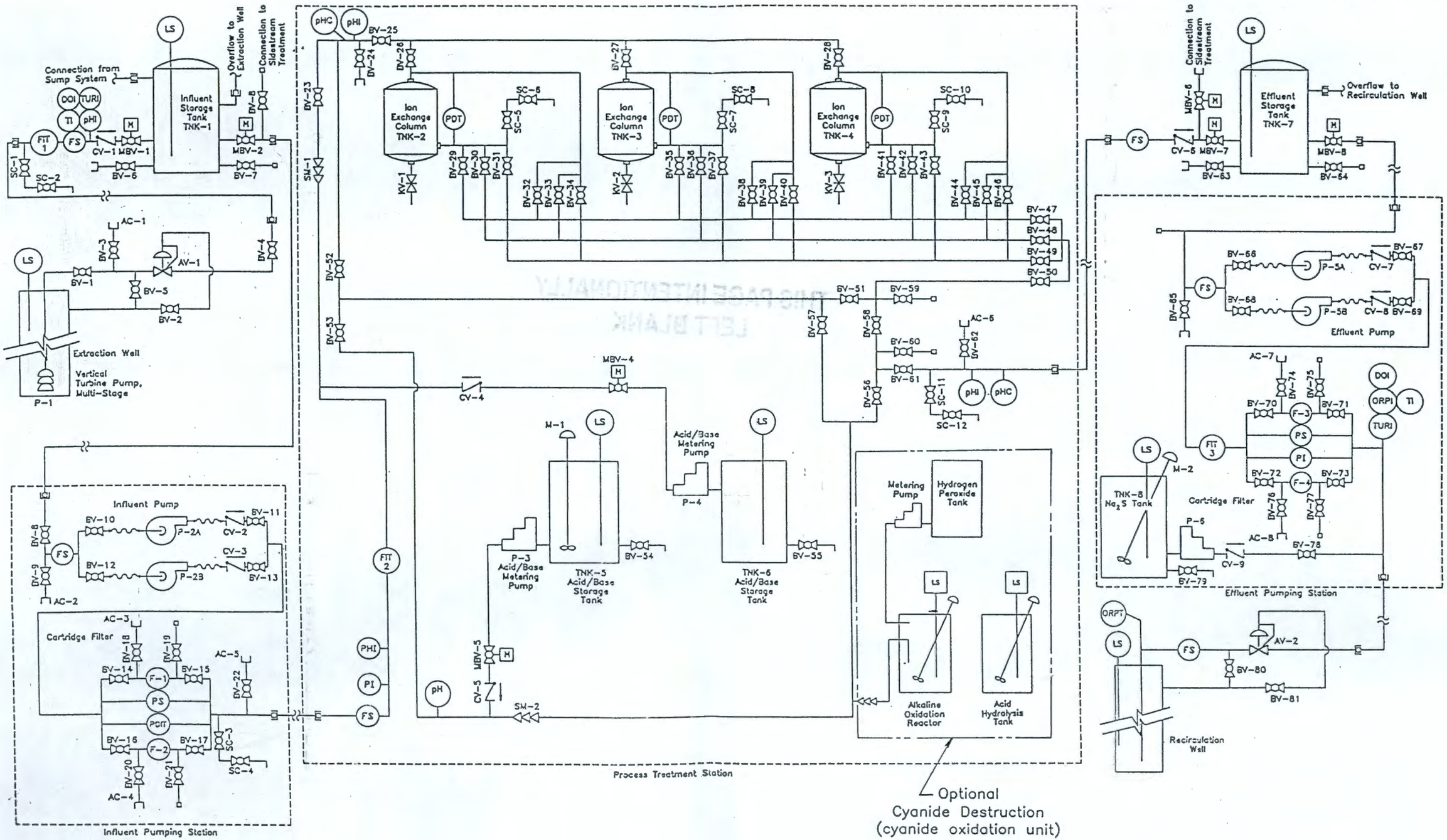

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Table 4-1. Summary of Construction Information for Existing Wells in the Vicinity of the 216-BY Cribs IRM Plume.

Well Number (699-)	Minimum Diameter (in)	Measured Depth to Bottom (ft)[d]	Depth of Screened Interval (ft)	Depth of Perforated Interval (ft)	Depth to Water (ft) (date)	Saturated Open Interval (ft)
47-60	8	274	n/a	235-277	250.1 (9/93)	250.1-274
48-50	4	179.7	159.4-179.7	n/a	170.8 (9/93)	170.8-179.7
49-55A	6	141	124-139	n/a	129.1 (6/93)	129.1-139
49-57A	8	164.6	n/a	144-161	152.1 (9/93)	152.1-161
50-53A	8	159	n/a	142-156.5	155.8 (9/93)	155.8-156.6
52-54	4	166.8	156.2-166.8	n/a	167.0 (9/93)	note[e]
52-57	4	159.5	149-159.5	n/a	160.7 (9/93)	note[e]
53-55A[a]	8[b]	202.1	n/a	165-202.1	175.3 (6/93)	175.3-202.1
53-55B[a]	8	256.7	n/a	232-252	176.3 (10/93)	232-252
53-55C[a]	10	220.5	197.3-220.5	n/a	175.0 (9/93)	197.3-220.5
55-55	4	169.3	148.4-169.3	n/a	162.7 (9/93)	162.8-169.3
55-57	6	180	n/a	139-169	167.0 (9/93)	167.0-169
57-59	4	189.0	166.0-186.3	n/a	175.1 (9/93)	175.1-186.3
59-58	6	110.2	85-105	n/a	97.0 (6/93)	97-105
60-57	6	151	60-70 [c]	n/a	68.7 (9/93)	68.7-70
60-60	8	125.6	n/a	100-125.6	111.4 (9/93)	111.4-125.6

[a] Located in erosional window.
[b] 2-in. piezometer tube also in well
[c] blank section 7-127 ft
[d] Bottom is considered bottom of perforations/screen
[e] Water level reported below measured depth of well during 9/93 sampling; groundwater samples were collected.

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Table 4-2. Summary of Construction Information for Existing Wells in the Vicinity of the 216-B-5 Reverse Well IRM Plume.

Well Number (299-)	Minimum Diameter (in.)	Depth to Bottom (ft)	Depth of Screened Interval (ft)	Depth of Perforated Interval (ft)	Depth to Water (ft) (date)	Saturated Open Interval (ft)
E28-1	8	322	273-322	277-324	283 (4/93)	283-322
E28-2	8	322.5	N/A	288-318	276 (3/92)	288-318
E28-3	8	326	N/A	314-324	-	314-324
E28-4	8	321	N/A	295-321	287 (6/93)	295-321
E28-5	6	327	N/A	259-304	270 (3/93)	270-304
E28-7	6	338	N/A	270-335	282 (6/93)	282-335
E28-8	8	315	N/A	250-294	-[a]	-
E28-10	8	325	N/A	257-309	270 (3/88)	270-309
E28-23	4	328	278-328	N/A	285 (3/93)	285-328
E28-24	4	329	277-327	N/A	284 (9/93)	-327
E28-25	4	329	279-329	N/A	284 (9/93)	284-329
E28-27	4	301.5	270-290 291-301	N/A	279 (8/93)	279-290 291-301

To convert feet to meters, multiply by 0.3048.

[a] Rock bridge at a depth of 263 ft; water level was not determined.

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5.0 SUPPORTING DOCUMENTS

Supporting documents include the 200 East Groundwater AAMSR (DOE-RL 1993a), the B Plant AAMSR (DOE-RL 1993b), and the *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit* (DOE-RL 1993c). Supporting documents in the 200 East Groundwater AAMSR (DOE-RL 1993a) include a health and safety plan, a project management plan, and a data management plan. These supporting plans will be applicable to all treatability test work scope performed by WHC within the 200-BP-5 Operable Unit.

Community relation activities in support of this treatability test will be performed as specified in the Tri-Party Agreement (Ecology et al. 1989b). A Cultural Resources Review and an Ecological Survey have been performed in support of the proposed 200-BP-5 Operable Unit treatability test sites. This treatability test study is being considered for Categorical Exclusion under the National Environmental Policy Act.

Additional documents will be developed in support of the 200-BP-5 Operable Unit treatability test prior to initiation of testing. These documents include:

- Treatability test system operating procedures
- Treatability test system sampling and analysis plan
- Treatability test system quality assurance project plan.

In addition, supporting documents will be developed to support groundwater sampling, groundwater monitoring, and other project related activities as necessary.

Finally, to address site- and program-specific requirements, WHC will prepare the following task-specific documents/permits:

- Hazardous waste operation permit: Addresses and mitigates site-specific health and safety hazards, provides for emergency response and sets forth personnel training requirements necessary for site entry.
- Radiation work permit: Addresses specific radiological control requirements for conducting the test.
- Safety analysis plan: Addresses global safety and environmental issues associated with plant operations (e.g., impacts resulting from tank failure) and specifies appropriate safety requirements for mitigation of these impacts.
- Waste control plan: Addresses identification of, and management and disposition procedures for wastes generated during field operations.

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6.0 REPORTS

A treatability test report will be prepared summarizing the results of the pilot-scale test. The format of the report will be based on the suggested outline for treatability test reports provided in the *Guide for Conducting Treatability Studies under CERCLA* (EPA 1992). The schedule for finalizing the treatability test report will be dependent on laboratory turn-around times for chemical analyses and may parallel the preparation and review of the IRM Proposed Plan. In addition, monthly project briefings will be given at unit manager meetings between DOE, EPA, and Ecology.

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7.0 SCHEDULE

Figure 7-1 shows the schedule for planning and performing the laboratory-scale tests and field pilot-scale treatability tests for each test site. The planned start of the pilot-scale treatment testing is August 31, 1994 pending approval of this treatability test plan. This schedule is contingent on demonstrating adequate well capacity, approval of the well recommendations and waste control plan, and addressing all safety concerns.

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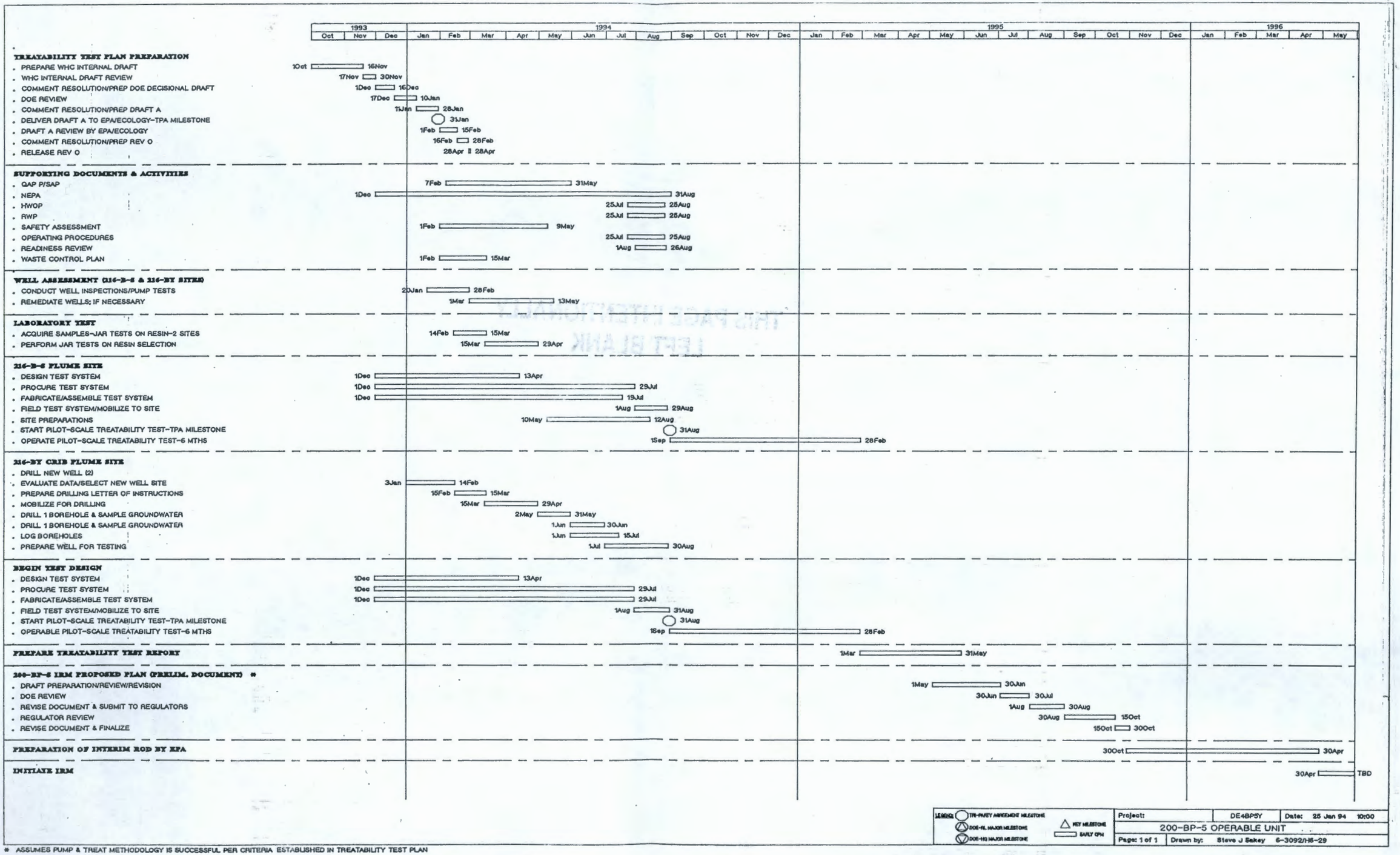
Figure 7-1. 200-BP-5 Operable Unit Treatability Test Schedule.



* ASSUMES PUMP & TREAT METHODOLOGY IS SUCCESSFUL PER CRITERIA ESTABLISHED IN TREATABILITY TEST PLAN

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8.0 PROGRAM ORGANIZATION

Figure 8-1 shows the organization for performing all phases of the pilot-scale treatability tests. Westinghouse Hanford Company Environmental Restoration Engineering will have direct responsibility for the planning, execution, and evaluation of the laboratory and field tests. Other WHC organizations will be used for various aspects of drilling and sampling activities.

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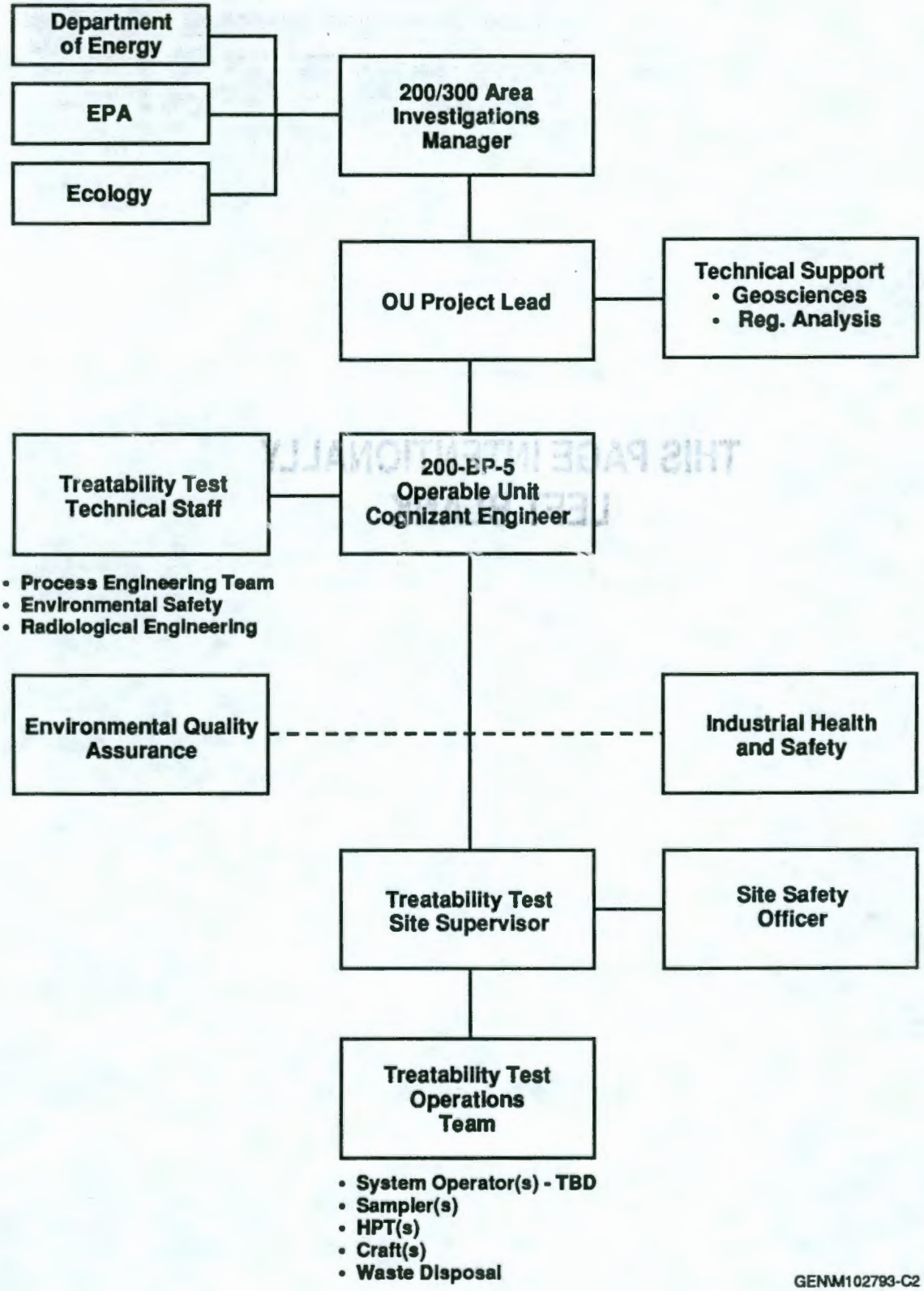
Figure 8-1. 200-BP-5 Operable Unit Treatability Test Program Organization.



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APPENDIX A

CONSTITUENT DETECTIONS FOR WELLS IN THE VICINITY OF THE 216-BY CRIBS AND 216-B-5 REVERSE WELL IRM PLUMES

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
299-E28-23	Alkalinity	ppb	96850.0	95600.0	98100	2	2
299-E28-23	Americium-241	pCi/L	.2	.1	0	2	1
299-E28-23	Ammonium ion	ppb	50.0	50.0	50	2	1
299-E28-23	Antimony, filtered	ppb	125.0	100.0	200	4	3
299-E28-23	Antimony-125	pCi/L	46.0	.1	116	3	2
299-E28-23	Barium	ppb	11.3	.0	20	3	2
299-E28-23	Barium, filtered	ppb	15.0	8.0	20	4	3
299-E28-23	Beryllium, filtered	ppb	4.5	3.0	5	4	3
299-E28-23	Boron	ppb	.0	.0	0	1	1
299-E28-23	Boron, filtered	ppb	25.0	25.0	25	1	1
299-E28-23	Bromide	ppb	500.0	500.0	500	2	1
299-E28-23	Cadmium, filtered	ppb	4.0	2.0	10	4	3
299-E28-23	Calcium	ppb	18675.3	25.9	30000	3	3
299-E28-23	Calcium, filtered	ppb	26625.0	22000.0	29700	4	4
299-E28-23	Cesium-137	pCi/L	1435.3	844.0	2080	12	12
299-E28-23	Chloride	ppb	17460.0	11000.0	21000	5	5
299-E28-23	Chromium, filtered	ppb	12.5	10.0	20	4	3
299-E28-23	Cobalt, filtered	ppb	20.0	20.0	20	2	1
299-E28-23	Cobalt-60	pCi/L	25.8	.1	228	12	10
299-E28-23	Copper, filtered	ppb	12.5	10.0	20	4	3
299-E28-23	Cyanide	ppb	13.3	10.0	20	3	2
299-E28-23	Cyanide, filtered	ppb	13.3	10.0	20	3	2
299-E28-23	Fluoride	ppb	500.0	500.0	500	2	2
299-E28-23	Fluorine	ppb	565.0	500.0	695	3	2
299-E28-23	Gross alpha	pCi/L	31.8	16.9	48	11	11
299-E28-23	Gross beta	pCi/L	11935.5	7660.0	20000	11	11
299-E28-23	Iodine-129	pCi/L	4.3	2.5	7	3	3
299-E28-23	Iron	ppb	38.7	.1	73	3	3
299-E28-23	Iron, filtered	ppb	56.3	25.0	100	4	4
299-E28-23	Magnesium	ppb	5862.6	7.9	9380	3	3
299-E28-23	Magnesium, filtered	ppb	8362.5	7700.0	9100	4	4
299-E28-23	Manganese	ppb	5.0	.0	10	2	1
299-E28-23	Manganese, filtered	ppb	6.3	5.0	10	4	3
299-E28-23	Nickel, filtered	ppb	15.0	10.0	30	4	3
299-E28-23	Nitrate	ppb	8598.0	6300.0	10700	10	10
299-E28-23	Nitrite	ppb	200.0	200.0	200	2	1
299-E28-23	Phosphate	ppb	760.0	400.0	1000	5	3
299-E28-23	Plutonium-238	pCi/L	.3	.0	2	11	10
299-E28-23	Plutonium-239/40	pCi/L	58.4	7.2	449	11	11
299-E28-23	Potassium	ppb	4851.6	4.9	7400	3	3
299-E28-23	Potassium, filtered	ppb	6912.5	6260.0	7530	4	4
299-E28-23	Ruthenium-106	pCi/L	98.2	.1	571	12	10
299-E28-23	Silver, filtered	ppb	12.5	10.0	20	4	3
299-E28-23	Sodium	ppb	14707.3	22.0	22100	3	3

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
299-E28-23	Sodium, filtered	ppb	21250.0	19400.0	23600	4	4
299-E28-23	Specific conductance	umhos	319.3	296.0	386	11	11
299-E28-23	Strontium, filtered	ppb	132.3	127.0	137	3	3
299-E28-23	Strontium-90	pCi/L	4636.7	284.0	7890	11	11
299-E28-23	Sulfate	ppb	31000.0	27800.0	39300	5	5
299-E28-23	Technetium-99	pCi/L	66.9	21.9	142	5	5
299-E28-23	Temperature, field	DegC	17.6	16.7	18	8	8
299-E28-23	Tin, filtered	ppb	65.0	30.0	100	2	1
299-E28-23	Total Carbon	ppb	22400.0	20500.0	24300	2	2
299-E28-23	Total Organic Carbon	ppb	733.8	400.0	1000	4	2
299-E28-23	Total Organic Halogen	ppb	14.6	9.0	29	4	3
299-E28-23	Trichloroethene	ppb	.2	.2	0	1	1
299-E28-23	Tritium	pCi/L	6529.2	3160.0	8170	12	12
299-E28-23	Uranium	pCi/L	22.3	14.5	28	5	5
299-E28-23	Uranium	ppb	24.5	17.3	34	3	3
299-E28-23	Uranium-234	pCi/L	9.1	8.5	10	2	2
299-E28-23	Uranium-235	pCi/L	.3	.2	0	3	3
299-E28-23	Uranium-238	pCi/L	7.1	2.9	10	[illegible]	3
299-E28-23	Vanadium	ppb	19.0	19.0	19	1	1
299-E28-23	Vanadium, filtered	ppb	22.0	17.0	30	4	3
299-E28-23	Zinc	ppb	19.0	19.0	19	1	1
299-E28-23	Zinc, filtered	ppb	7.0	5.0	13	4	3
299-E28-23	pH	pH	8.1	7.7	9	13	13
299-E28-24	Aluminum	ppb	140000.0	140000.0	140000	1	1
299-E28-24	Americium-241	pCi/L	.6	.6	1	1	1
299-E28-24	Antimony	ppb	110.0	110.0	110	1	1
299-E28-24	Barium	ppb	1400.0	1400.0	1400	1	1
299-E28-24	Beryllium	ppb	8.3	8.3	8	1	1
299-E28-24	Bromide	ppb	450.0	400.0	500	2	1
299-E28-24	Cadmium	ppb	300.0	300.0	300	1	1
299-E28-24	Calcium	ppb	180000.0	180000.0	180000	1	1
299-E28-24	Cesium-137	pCi/L	112.6	.1	633	6	5
299-E28-24	Chloride	ppb	193250.0	180000.0	200000	4	4
299-E28-24	Chloride	ppm	202.0	202.0	202	1	1
299-E28-24	Chromium	ppb	770.0	770.0	770	1	1
299-E28-24	Cobalt	ppb	220.0	220.0	220	1	1
299-E28-24	Cobalt-60	pCi/L	1.8	.1	6	6	5
299-E28-24	Copper	ppb	850.0	850.0	850	1	1
299-E28-24	Fluoride	ppb	2500.0	2300.0	2700	3	3
299-E28-24	Fluoride	ppm	1.4	1.4	1	1	1
299-E28-24	Fluorine	ppb	2200.0	2200.0	2200	1	1
299-E28-24	Gross alpha	pCi/L	152.0	.1	1250	9	8
299-E28-24	Gross beta	pCi/L	306.4	252.0	349	7	7

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
299-E28-24	Iron	ppb	720000.0	720000.0	720000	1	1
299-E28-24	Magnesium	ppb	73000.0	73000.0	73000	1	1
299-E28-24	Manganese	ppb	11000.0	11000.0	11000	1	1
299-E28-24	Nickel	ppb	650.0	650.0	650	1	1
299-E28-24	Nitrate	ppb	200.0	200.0	200	2	1
299-E28-24	Nitrite	ppb	119.1	38.3	200	2	1
299-E28-24	Phosphate	ppb	273.5	147.0	400	2	1
299-E28-24	Plutonium-238	pCi/L	.2	.0	1	9	8
299-E28-24	Plutonium-239/40	pCi/L	32.4	.1	144	9	9
299-E28-24	Potassium	ppb	43000.0	43000.0	43000	1	1
299-E28-24	Ruthenium-106	pCi/L	2.7	.1	16	6	5
299-E28-24	Silver	ppb	29.0	29.0	29	1	1
299-E28-24	Sodium	ppb	98000.0	98000.0	98000	1	1
299-E28-24	Specific conductance	umhos	824.0	735.0	1028	8	8
299-E28-24	Strontium-90	pCi/L	196.2	146.0	328	6	6
299-E28-24	Sulfate	ppb	666.7	500.0	900	3	2
299-E28-24	Sulfate	ppm	.3	.3	0	1	1
299-E28-24	Temperature, field	Deg	17.6	15.9	19	[illegible]	6
299-E28-24	Total Organic Carbon	ppb	9000.0	9000.0	9000	1	1
299-E28-24	Total Organic Halogen	ppb	28.5	17.0	40	2	2
299-E28-24	Tritium	pCi/L	61916.7	56900.0	71100	6	6
299-E28-24	Uranium	pCi/L	.6	.2	2	7	6
299-E28-24	Uranium-234	pCi/L	.2	.1	0	3	3
299-E28-24	Uranium-235	pCi/L	.1	.0	0	3	2
299-E28-24	Uranium-238	pCi/L	.2	.1	0	3	3
299-E28-24	Vanadium	ppb	490.0	490.0	490	1	1
299-E28-24	Zinc	ppb	2100.0	2100.0	2100	1	1
299-E28-24	pH	pH	8.2	6.8	9	8	8
299-E28-25	Aluminum	ppb	2300.0	2300.0	2300	1	1
299-E28-25	Americium-241	pCi/L	.2	.2	0	1	1
299-E28-25	Barium	ppb	71.0	71.0	71	1	1
299-E28-25	Bromide	ppb	276.4	52.8	500	2	1
299-E28-25	Calcium	ppb	39000.0	39000.0	39000	1	1
299-E28-25	Cesium-137	pCi/L	288.0	34.7	1070	7	7
299-E28-25	Chloride	ppb	13325.0	10000.0	20300	4	4
299-E28-25	Chromium	ppb	97.0	97.0	97	1	1
299-E28-25	Cobalt-60	pCi/L	2.7	.1	8	6	5
299-E28-25	Copper	ppb	53.0	53.0	53	1	1
299-E28-25	Fluoride	ppb	500.0	400.0	600	3	3
299-E28-25	Gross alpha	pCi/L	26.1	8.7	72	9	9
299-E28-25	Gross beta	pCi/L	9194.3	7160.0	12000	7	7
299-E28-25	Iron	ppb	20000.0	20000.0	20000	1	1
299-E28-25	Magnesium	ppb	11000.0	11000.0	11000	1	1

Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	% D.L.
299-E28-25	Manganese	ppb	220.0	220.0	220	1	1
299-E28-25	Nickel	ppb	44.0	44.0	44	1	1
299-E28-25	Nitrate	ppb	8925.0	7200.0	12000	4	4
299-E28-25	Nitrite	ppb	119.1	38.3	200	2	1
299-E28-25	Phosphate	ppb	273.5	147.0	400	2	1
299-E28-25	Plutonium-238	pCi/L	.1	.0	0	10	8
299-E28-25	Plutonium-239/40	pCi/L	27.5	1.1	125	10	10
299-E28-25	Potassium	ppb	5600.0	5600.0	5600	1	1
299-E28-25	Ruthenium-106	pCi/L	9.4	.1	28	6	5
299-E28-25	Sodium	ppb	22000.0	22000.0	22000	1	1
299-E28-25	Specific conductance	umhos	316.9	285.0	334	7	7
299-E28-25	Strontium-90	pCi/L	5148.6	3150.0	6270	7	7
299-E28-25	Sulfate	ppb	29600.0	28400.0	31000	4	4
299-E28-25	Temperature, field	Deg C	16.8	14.6	19	5	5
299-E28-25	Total Organic Carbon	ppb	700.0	700.0	700	1	1
299-E28-25	Total Organic Halogen	ppb	3.5	1.0	8	2	1
299-E28-25	Tritium	pCi/L	3994.0	2070.0	6280	5	5
299-E28-25	Uranium	pCi/L	15.1	7.7	31	7	7
299-E28-25	Uranium	ppb	9.0	3.0	9	1	1
299-E28-25	Uranium-234	pCi/L	6.6	5.4	8	3	3
299-E28-25	Uranium-235	pCi/L	.3	.2	0	3	3
299-E28-25	Uranium-238	pCi/L	6.5	5.2	8	3	3
299-E28-25	Vanadium	ppb	39.0	39.0	39	1	1
299-E28-25	Zinc	ppb	180.0	180.0	180	1	1
299-E28-25	pH	pH	7.8	6.4	8	7	7
299-E28-7	Acetone	ppb	140.0	140.0	140	1	1
299-E28-7	Alkalinity	ppb	96600.0	96600.0	96600	1	1
299-E28-7	Aluminum	ppb	304.0	304.0	304	1	1
299-E28-7	Barium	ppb	53.0	53.0	53	1	1
299-E28-7	Cadmium	ppb	9.0	9.0	9	1	1
299-E28-7	Calcium	ppb	32400.0	32400.0	32400	1	1
299-E28-7	Cesium-137	pCi/L	4.0	.1	23	8	7
299-E28-7	Chloride	ppb	16750.0	11000.0	22000	4	4
299-E28-7	Chromium	ppb	10.0	10.0	10	1	1
299-E28-7	Cobalt-60	pCi/L	3.7	.1	10	8	7
299-E28-7	Fluoride	ppb	550.0	500.0	600	2	2
299-E28-7	Fluorine	ppb	500.0	500.0	500	2	1
299-E28-7	Gross alpha	pCi/L	1.9	.7	4	8	7
299-E28-7	Gross beta	pCi/L	148.0	116.0	218	8	8
299-E28-7	Iodine-129	pCi/L	1.0	.8	1	2	2
299-E28-7	Iron	ppb	15800.0	15800.0	15800	1	1
299-E28-7	Magnesium	ppb	10300.0	10300.0	10300	1	1
299-E28-7	Manganese	ppb	259.0	259.0	259	1	1

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
299-E28-7	Nitrate	ppb	6882.9	4600.0	8290	7	7
299-E28-7	Phosphate	ppb	1000.0	1000.0	1000	2	1
299-E28-7	Plutonium-238	pCi/L	.1	.0	0	8	7
299-E28-7	Plutonium-239/40	pCi/L	.0	.0	0	8	7
299-E28-7	Potassium	ppb	6370.0	6370.0	6370	1	1
299-E28-7	Radium	pCi/L	.2	.2	0	1	1
299-E28-7	Ruthenium-106	pCi/L	4.9	.1	16	8	7
299-E28-7	Sodium	ppb	24700.0	24700.0	24700	1	1
299-E28-7	Specific conductance	umhos	353.0	194.0	509	7	7
299-E28-7	Strontium	ppb	166.0	166.0	166	1	1
299-E28-7	Strontium-90	pCi/L	75.6	46.0	113	9	9
299-E28-7	Sulfate	ppb	36400.0	32000.0	40500	4	4
299-E28-7	Technetium-99	pCi/L	92.4	61.4	136	3	3
299-E28-7	Temperature, field	DegC	17.3	16.4	19	6	6
299-E28-7	Toluene	ppb	20.0	20.0	20	1	1
299-E28-7	Total Carbon	ppb	24200.0	24200.0	24200	1	1
299-E28-7	Total Organic Halogen	ppb	14.3	7.0	22	2	1
299-E28-7	Tritium	pCi/L	5406.3	2830.0	7940	8	8
299-E28-7	Uranium	pCi/L	2.4	.7	5	7	7
299-E28-7	Uranium-234	pCi/L	1.3	.5	2	4	4
299-E28-7	Uranium-235	pCi/L	.0	.0	0	4	3
299-E28-7	Uranium-238	pCi/L	1.0	.4	2	4	4
299-E28-7	Vanadium	ppb	36.0	36.0	36	1	1
299-E28-7	Zinc	ppb	16.0	16.0	16	1	1
299-E28-7	pH	pH	7.6	6.6	8	8	8
299-E33-7	4-Methyl-2-pentanone	ppb	1.0	1.0	1	1	1
299-E33-7	Acetone	ppb	6.0	6.0	6	1	1
299-E33-7	Aluminum	ppb	80.0	64.0	91	5	4
299-E33-7	Antimony	ppb	27.4	18.0	57	5	4
299-E33-7	Antimony, filtered	ppb	18.5	18.0	19	2	1
299-E33-7	Arsenic	ppb	8.9	6.7	11	8	8
299-E33-7	Arsenic, filtered	ppb	6.8	6.7	7	2	2
299-E33-7	Barium	ppb	24.4	17.9	38	7	7
299-E33-7	Barium, filtered	ppb	21.9	21.7	22	2	2
299-E33-7	Beryllium	ppb	1.0	1.0	1	5	4
299-E33-7	Beryllium, filtered	ppb	1.0	1.0	1	2	1
299-E33-7	Bis(2-ethylhexyl) phthalate	ppb	2.0	2.0	2	1	1
299-E33-7	Cadmium	ppb	3.4	2.0	4	6	5
299-E33-7	Cadmium, filtered	ppb	3.0	2.0	4	2	1
299-E33-7	Calcium	ppb	38857.1	31200.0	43700	7	7
299-E33-7	Calcium, filtered	ppb	39300.0	39100.0	39500	2	2
299-E33-7	Cesium-137	pCi/L	1.8	.1	6	7	6
299-E33-7	Chloride	ppb	4700.0	4700.0	4700	1	1

Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
299-E33-7	Chloride	ppm	5.3	5.3	5	1	1
299-E33-7	Chromium	ppb	20.7	6.8	34	8	8
299-E33-7	Chromium, filtered	ppb	11.4	8.9	14	2	2
299-E33-7	Cobalt	ppb	6.0	3.0	10	5	4
299-E33-7	Cobalt, filtered	ppb	3.5	3.0	4	2	1
299-E33-7	Cobalt-60	pCi/L	46.8	26.3	71	7	7
299-E33-7	Copper	ppb	9.5	6.0	14	6	5
299-E33-7	Copper, filtered	ppb	5.3	3.6	7	2	1
299-E33-7	Cyanide	ppb	33.5	28.6	39	5	4
299-E33-7	Fluoride	ppb	1100.0	1100.0	1100	1	1
299-E33-7	Gross alpha	pCi/L	2.5	2.5	2	1	1
299-E33-7	Gross beta	pCi/L	491.3	312.0	723	7	7
299-E33-7	Iodine-129	pCi/L	.4	.4	1	2	2
299-E33-7	Iron	ppb	279.0	[illegible]	589	8	7
299-E33-7	Iron, filtered	ppb	41.4	37.0	46	2	1
299-E33-7	Lead	ppb	2.2	2.0	[illegible]	7	6
299-E33-7	Lead, filtered	ppb	2.0	2.0	2	2	[illegible]
299-E33-7	Magnesium	ppb	[illegible]405.0	[illegible]0	12000	8	8
299-E33-7	Magnesium, filtered	ppb	[illegible]	10800.0	11100	2	2
299-E33-7	Manganese	ppb	5.2	2.0	12	8	7
299-E33-7	Manganese, filtered	ppb	2.3	2.0	3	2	1
299-E33-7	Mercury	ppb	.3	.2	0	7	7
299-E33-7	Mercury, filtered	ppb	.3	.3	0	2	2
299-E33-7	Methylene chloride	ppb	3.0	3.0	3	1	1
299-E33-7	Nickel	ppb	12.5	7.0	19	6	5
299-E33-7	Nickel, filtered	ppb	6.5	6.0	7	2	1
299-E33-7	Nitrate	ppb	92200.0	67000.0	119000	4	4
299-E33-7	Nitrate	ppm	129.0	129.0	129	1	1
299-E33-7	Potassium	ppb	6154.3	4590.0	6970	7	7
299-E33-7	Potassium, filtered	ppb	5890.0	5890.0	5890	1	1
299-E33-7	Ruthenium-106	pCi/L	8.5	.1	44	7	6
299-E33-7	Selenium	ppb	1.9	1.0	2	6	5
299-E33-7	Selenium, filtered	ppb	1.5	1.0	2	2	1
299-E33-7	Silver	ppb	5.8	4.0	10	6	5
299-E33-7	Silver, filtered	ppb	4.0	4.0	4	2	1
299-E33-7	Sodium	ppb	27850.0	21200.0	31600	8	8
299-E33-7	Sodium, filtered	ppb	28800.0	28100.0	29500	2	2
299-E33-7	Specific conductance	umhos	413.7	360.0	442	6	6
299-E33-7	Strontium-90	pCi/L	.8	.1	3	7	6
299-E33-7	Sulfate	ppb	34000.0	34000.0	34000	1	1
299-E33-7	Sulfate	ppm	36.0	36.0	36	1	1
299-E33-7	Technetium-99	pCi/L	2617.2	3.2	4460	5	5
299-E33-7	Temperature, field	DegC	17.8	17.1	19	7	7
299-E33-7	Thallium	ppb	6.2	2.0	20	5	4
299-E33-7	Thallium, filtered	ppb	3.5	2.0	5	2	1

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
299-E33-7	Tritium	pCi/L	6180.0	2930.0	10900	6	6
299-E33-7	Uranium	pCi/L	1.9	1.5	2	3	3
299-E33-7	Uranium	ppb	1.8	1.8	2	2	2
299-E33-7	Vanadium	ppb	30.0	22.3	37	7	7
299-E33-7	Vanadium, filtered	ppb	30.4	30.4	30	1	1
299-E33-7	Zinc	ppb	14.3	6.0	23	7	6
299-E33-7	Zinc, filtered	ppb	9.2	6.7	12	2	2
299-E33-7	pH	pH	7.7	7.0	8	8	8
699-49-55A	1,1,1,2-Tetrachloroethane	ppb	10.0	10.0	10	2	1
699-49-55A	1,1,1-Trichloroethane	ppb	6.3	5.0	10	4	2
699-49-55A	1,1,2,2-Tetrachloroethane	ppb	10.0	10.0	10	2	1
699-49-55A	1,1,2-Trichloroethane	ppb	6.3	5.0	10	4	2
699-49-55A	1,1-Dichloroethane	ppb	8.8	5.0	10	4	2
699-49-55A	1,1-Dichloroethene	ppb	8.8	5.0	10	4	2
699-49-55A	1,2,3,4-tetrachlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,2,3,5-tetrachlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,2,3-Trichloropropane	ppb	10.0	10.0	10	2	1
699-49-55A	1,2,3-trichlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,2,4,5-Tetrachlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,2,4-Trichlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,2-Dibromo-3-chloropropane	ppb	10.0	10.0	10	2	1
699-49-55A	1,2-Dibromoethane	ppb	10.0	10.0	10	2	1
699-49-55A	1,2-Dichlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,2-Dichloroethane	ppb	8.8	5.0	10	4	2
699-49-55A	1,2-Dichloroethene	ppb	7.5	5.0	10	2	1
699-49-55A	1,2-Dichloropropane	ppb	8.8	5.0	10	4	2
699-49-55A	1,3,5-trichlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,3-Dichlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,3-Dichloropropene	ppb	10.0	10.0	10	2	1
699-49-55A	1,4-Dichlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	1,4-Dioxane	ppb	500.0	500.0	500	2	1
699-49-55A	2-Chloroethyl vinyl ether	ppb	10.0	10.0	10	2	1
699-49-55A	2-Hexanone	ppb	10.0	10.0	10	2	1
699-49-55A	4-Methyl-2-pentanone	ppb	10.0	10.0	10	2	1
699-49-55A	Acetone	ppb	16.0	10.0	28	3	2
699-49-55A	Acetonitrile	ppb	3000.0	3000.0	3000	2	1
699-49-55A	Acrolein	ppb	10.0	10.0	10	2	1
699-49-55A	Acrylonitrile	ppb	10.0	10.0	10	2	1
699-49-55A	Alkalinity	ppb	103555.6	96300.0	111000	9	9
699-49-55A	Aluminum	ppb	78.7	49.0	96	7	6
699-49-55A	Ammonium ion	ppb	1109.4	800.0	1490	5	5
699-49-55A	Antimony	ppb	36.3	19.0	60	7	6
699-49-55A	Antimony, filtered	ppb	79.0	19.0	100	6	4

Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-49-55A	Antimony-125	pCi/L	3.7	.1	12	5	4
699-49-55A	Arsenic	ppb	5.9	2.0	7	11	11
699-49-55A	Arsenic, filtered	ppb	5.5	5.0	6	5	4
699-49-55A	Barium	ppb	31.8	26.6	38	11	11
699-49-55A	Barium, filtered	ppb	38.5	32.0	45	9	9
699-49-55A	Benzene	ppb	6.3	5.0	10	4	2
699-49-55A	Beryllium	ppb	1.0	1.0	1	7	6
699-49-55A	Beryllium, filtered	ppb	3.7	1.0	5	6	4
699-49-55A	Bis(2-ethylhexyl) phthalate	ppb	3.0	3.0	3	1	1
699-49-55A	Bis(chloromethyl) ether	ppb	10.0	10.0	10	2	1
699-49-55A	Boron, filtered	ppb	21.3	19.0	24	3	3
699-49-55A	Bromide	ppb	642.5	70.0	1000	4	2
699-49-55A	Bromoacetone	ppb	10.0	10.0	10	2	0
699-49-55A	Bromodichloromethane	ppb	7.5	5.0	10	2	1
699-49-55A	Bromoform	ppb	8.8	5.0	10	4	2
699-49-55A	Cadmium	ppb	4.0	3.0	7	7	6
699-49-55A	Cadmium, filtered	ppb	2.7	2.0	4	7	5
699-49-55A	Calcium	ppb	52866.7	46000.0	58200	12	12
699-49-55A	Calcium, filtered	ppb	76536.4	54000.0	99200	11	11
699-49-55A	Carbon disulfide	ppb	8.0	2.0	10	4	2
699-49-55A	Carbon tetrachloride	ppb	6.3	5.0	10	4	2
699-49-55A	Cesium-137	pCi/L	.5	.1	5	15	13
699-49-55A	Chloride	ppb	12500.0	10700.0	15200	11	11
699-49-55A	Chloride	ppm	11.9	11.9	12	1	1
699-49-55A	Chlorobenzene	ppb	8.8	5.0	10	4	2
699-49-55A	Chloroethane	ppb	10.0	10.0	10	2	1
699-49-55A	Chloroform	ppb	6.3	5.0	10	4	2
699-49-55A	Chloromethyl methyl ether	ppb	10.0	10.0	10	2	1
699-49-55A	Chromium	ppb	23.5	6.0	112	12	11
699-49-55A	Chromium, filtered	ppb	7.9	3.5	10	6	4
699-49-55A	Cobalt	ppb	7.7	4.0	10	7	6
699-49-55A	Cobalt, filtered	ppb	6.0	4.0	8	2	1
699-49-55A	Cobalt-60	pCi/L	78.0	.1	222	15	15
699-49-55A	Copper	ppb	8.1	6.0	10	7	6
699-49-55A	Copper, filtered	ppb	8.8	6.0	10	6	4
699-49-55A	Crotonaldehyde	ppb	10.0	10.0	10	2	1
699-49-55A	Cyanide	ppb	73.8	10.0	247	24	22
699-49-55A	Cyanide, filtered	ppb	95.5	10.0	247	17	16
699-49-55A	Dibromochloromethane	ppb	7.5	5.0	10	2	1
699-49-55A	Dibromomethane	ppb	10.0	10.0	10	2	1
699-49-55A	Dichlorodifluoromethane	ppb	10.0	10.0	10	2	1
699-49-55A	Diethylarsine	ppb	10.0	10.0	10	2	1
699-49-55A	Ethyl methacrylate	ppb	10.0	10.0	10	2	1
699-49-55A	Ethylbenzene	ppb	7.5	5.0	10	2	1
699-49-55A	Ethylene oxide	ppb	3000.0	3000.0	3000	2	1

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-49-55A	Fluoride	ppb	500.0	500.0	500	3	3
699-49-55A	Fluoride	ppm	.8	.8	1	1	1
699-49-55A	Fluorine	ppb	428.4	334.0	500	10	9
699-49-55A	Formaldehyde	ppb	500.0	500.0	500	2	1
699-49-55A	Gross alpha	pCi/L	2.8	1.7	3	10	9
699-49-55A	Gross beta	pCi/L	979.8	278.0	1550	10	10
699-49-55A	Hexachlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	Hexachlorophene	ppb	10.0	10.0	10	2	1
699-49-55A	Hydrogen sulfide	ppb	10.0	10.0	10	2	1
699-49-55A	Iodine-129	pCi/L	.1	.0	0	9	8
699-49-55A	Iron	ppb	209.5	42.5	729	12	11
699-49-55A	Iron, filtered	ppb	101.8	51.1	234	10	10
699-49-55A	Kerosene	ppb	10000.0	10000.0	10000	2	1
699-49-55A	Lead	ppb	4.5	2.0	20	8	7
699-49-55A	Lead, filtered	ppb	3.5	2.0	5	4	2
699-49-55A	Magnesium	ppb	14972.7	12700.0	16800	11	11
699-49-55A	Magnesium, filtered	ppb	21536.4	16000.0	26800	11	11
699-49-55A	Manganese	ppb	19.0	8.6	28	12	12
699-49-55A	Manganese, filtered	ppb	23.8	11.4	33	9	9
699-49-55A	Mercury	ppb	.1	.1	0	7	6
699-49-55A	Mercury, filtered	ppb	.1	.1	0	4	2
699-49-55A	Methacrylonitrile	ppb	10.0	10.0	10	2	1
699-49-55A	Methanethiol	ppb	10.0	10.0	10	2	1
699-49-55A	Methyl iodide	ppb	10.0	10.0	10	2	1
699-49-55A	Methyl bromide	ppb	10.0	10.0	10	2	1
699-49-55A	Methyl chloride	ppb	10.0	10.0	10	2	1
699-49-55A	Methyl ethyl ketone	ppb	10.0	10.0	10	2	1
699-49-55A	Methyl methacrylate	ppb	10.0	10.0	10	2	1
699-49-55A	Methylene chloride	ppb	12.8	10.0	21	4	2
699-49-55A	N,N-Diethylhydrazine	ppb	10.0	10.0	10	2	1
699-49-55A	Naphthalene	ppb	10.0	10.0	10	2	1
699-49-55A	Nickel	ppb	23.1	11.0	55	8	7
699-49-55A	Nickel, filtered	ppb	9.5	7.0	10	6	4
699-49-55A	Nitrate	ppb	133664.7	16100.0	242000	17	17
699-49-55A	Nitrate	ppm	40.9	40.9	41	1	1
699-49-55A	Nitrite	ppb	1000.0	1000.0	1000	2	1
699-49-55A	Pentachlorobenzene	ppb	10.0	10.0	10	2	1
699-49-55A	Pentachloroethane	ppb	10.0	10.0	10	2	1
699-49-55A	Phenol	ppb	10.0	10.0	10	2	1
699-49-55A	Phosphate	ppb	1000.0	1000.0	1000	5	4
699-49-55A	Potassium	ppb	9028.2	7700.0	10800	11	11
699-49-55A	Potassium, filtered	ppb	11311.0	9580.0	13100	10	10
699-49-55A	Pyridine	ppb	500.0	500.0	500	2	1
699-49-55A	Ruthenium-106	pCi/L	11.1	.1	35	15	13
699-49-55A	Selenium	ppb	4.3	2.0	10	12	12

Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-49-55A	Selenium, filtered	ppb	4.2	2.8	6	4	3
699-49-55A	Silver	ppb	14.2	4.0	61	8	7
699-49-55A	Silver, filtered	ppb	8.5	4.0	10	6	4
699-49-55A	Sodium	ppb	35083.3	30200.0	38100	12	12
699-49-55A	Sodium, filtered	ppb	43236.4	37200.0	48700	11	11
699-49-55A	Specific conductance	umhos	572.6	278.0	855	14	14
699-49-55A	Strontium, filtered	ppb	397.3	311.0	487	9	9
699-49-55A	Strontium-90	pCi/L	.2	.1	1	9	8
699-49-55A	Styrene	ppb	7.5	5.0	10	2	1
699-49-55A	Sulfate	ppb	126700.0	106000.0	144000	10	10
699-49-55A	Sulfate	ppm	108.0	108.0	108	1	1
699-49-55A	Technetium-99	pCi/L	4949.4	125.0	12500	5	5
699-49-55A	Temperature, field	DegC	17.4	15.0	19	14	14
699-49-55A	Tetrachloroethene	ppb	6.3	5.0	10	[illegible]	2
699-49-55A	Thallium	[illegible]	2.4	2.0	5	7	6
699-49-55A	Thallium, filtered	ppb	3.5	2.0	5	2	[illegible]
699-49-55A	Toluene	ppb	6.3	5.0	10	4	2
699-49-55A	Total Carbon	ppb	[illegible]	21600.0	25600	5	5
699-49-55[illegible]	Total Organic Carbon	ppb	440.0	[illegible]	[illegible]	4	3
699-49-55A	Total Organic Halogen	ppb	3.0	[illegible]	6	2	1
699-49-55A	Tributylphosphoric Acid	ppb	10.0	10.0	10	2	1
699-49-55A	Trichloroethene	ppb	6.3	5.0	10	4	2
699-49-55A	Trichloromethanethiol	ppb	10.0	10.0	10	2	1
699-49-55A	Trichloromonofluoromethane	ppb	10.0	10.0	10	2	1
699-49-55A	Tritium	pCi/L	6114.8	783.0	14800	16	16
699-49-55A	Uranium	pCi/L	2.9	2.0	4	10	10
699-49-55A	Vanadium	ppb	22.7	13.0	34	11	11
699-49-55A	Vanadium, filtered	ppb	14.1	8.0	32	7	7
699-49-55A	Vinyl chloride	ppb	10.0	10.0	10	2	1
699-49-55A	Xylenes (total)	ppb	6.3	5.0	10	4	2
699-49-55A	Zinc	ppb	8.1	4.0	18	9	8
699-49-55A	Zinc, filtered	ppb	7.2	3.0	14	9	7
699-49-55A	cis-1,3-Dichloropropene	ppb	7.5	5.0	10	2	1
699-49-55A	pH	pH	8.0	7.0	9	21	21
699-49-55A	trans-1,2-Dichloroethylene	ppb	10.0	10.0	10	2	1
699-49-55A	trans-1,3-Dichloropropene	ppb	7.5	5.0	10	2	1
699-49-55A	trans-1,4-dichloro-2-butene	ppb	10.0	10.0	10	2	1
699-50-53A	1,1,1,2-Tetrachloroethane	ppb	10.0	10.0	10	2	1
699-50-53A	1,1,1-Trichloroethane	ppb	6.3	5.0	10	4	2
699-50-53A	1,1,2,2-Tetrachloroethane	ppb	10.0	10.0	10	2	1
699-50-53A	1,1,2-Trichloroethane	ppb	6.3	5.0	10	4	2
699-50-53A	1,1-Dichloroethane	ppb	8.8	5.0	10	4	2
699-50-53A	1,1-Dichloroethene	ppb	8.8	5.0	10	4	2

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-50-53A	1,2,3,4-tetrachlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,2,3,5-tetrachlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,2,3-Trichloropropane	ppb	10.0	10.0	10	2	1
699-50-53A	1,2,3-trichlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,2,4,5-Tetrachlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,2,4-Trichlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,2-Dibromo-3-chloropropane	ppb	10.0	10.0	10	2	1
699-50-53A	1,2-Dibromoethane	ppb	10.0	10.0	10	2	1
699-50-53A	1,2-Dichlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,2-Dichloroethane	ppb	8.8	5.0	10	4	2
699-50-53A	1,2-Dichloroethene	ppb	7.5	5.0	10	2	1
699-50-53A	1,2-Dichloropropane	ppb	8.8	5.0	10	4	2
699-50-53A	1,3,5-trichlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,3-Dichlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,3-Dichloropropene	ppb	10.0	10.0	10	2	1
699-50-53A	1,4-Dichlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	1,4-Dioxane	ppb	500.0	500.0	500	2	1
699-50-53A	2-Chloroethyl vinyl ether	ppb	10.0	10.0	10	2	1
699-50-53A	2-Hexanone	ppb	10.0	10.0	10	2	1
699-50-53A	4-Methyl-2-pentanone	ppb	10.0	10.0	10	2	1
699-50-53A	Acetone	ppb	7.0	4.0	10	2	1
699-50-53A	Acetonitrile	ppb	3000.0	3000.0	3000	2	1
699-50-53A	Acrolein	ppb	10.0	10.0	10	2	1
699-50-53A	Acrylonitrile	ppb	10.0	10.0	10	2	1
699-50-53A	Alkalinity	ppb	67262.5	65300.0	68500	8	8
699-50-53A	Aluminum	ppb	109.0	46.0	200	9	8
699-50-53A	Americium-241	pCi/L	.0	.0	0	3	2
699-50-53A	Ammonium ion	ppb	68.5	55.0	82	2	2
699-50-53A	Antimony	ppb	45.0	20.0	74	9	8
699-50-53A	Antimony, filtered	ppb	96.3	19.0	200	7	5
699-50-53A	Antimony-125	pCi/L	5.1	.1	19	7	6
699-50-53A	Arsenic	ppb	3.8	2.1	10	11	11
699-50-53A	Arsenic, filtered	ppb	4.1	2.9	5	4	3
699-50-53A	Barium	ppb	79.2	.1	200	13	13
699-50-53A	Barium, filtered	ppb	77.4	66.0	100	11	11
699-50-53A	Benzene	ppb	6.3	5.0	10	4	2
699-50-53A	Beryllium	ppb	1.6	1.0	5	7	6
699-50-53A	Beryllium, filtered	ppb	3.6	1.0	5	7	5
699-50-53A	Beryllium-7	pCi/L	45.3	.1	91	2	1
699-50-53A	Bis(chloromethyl) ether	ppb	10.0	10.0	10	2	1
699-50-53A	Boron	ppb	.0	.0	0	1	1
699-50-53A	Boron, filtered	ppb	24.0	24.0	24	1	1
699-50-53A	Bromide	ppb	500.0	500.0	500	3	2
699-50-53A	Bromoacetone	ppb	10.0	10.0	10	2	1
699-50-53A	Bromodichloromethane	ppb	7.5	5.0	10	2	1

Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-50-53A	Bromoform	ppb	8.8	5.0	10	4	2
699-50-53A	Cadmium	ppb	4.3	3.0	7	6	5
699-50-53A	Cadmium, filtered	ppb	3.7	2.0	10	7	5
699-50-53A	Calcium	ppb	181741.4	297.0	285000	12	12
699-50-53A	Calcium, filtered	ppb	227183.3	31200.0	289000	12	12
699-50-53A	Carbon disulfide	ppb	8.8	5.0	10	4	2
699-50-53A	Carbon tetrachloride	ppb	6.3	5.0	10	4	2
699-50-53A	Cerium/Praseodymium-144	pCi/L	17.8	.1	36	2	1
699-50-53A	Cesium-134	pCi/L	1.1	.1	2	2	1
699-50-53A	Cesium-137	pCi/L	1.6	.1	6	15	13
699-50-53A	Chloride	ppb	37050.0	31900.0	48000	12	12
699-50-53A	Chloride	ppm	38.1	38.1	38	1	1
699-50-53A	Chlorobenzene	ppb	8.8	5.0	10	4	2
699-50-53A	Chloroethane	ppb	10.0	10.0	10	2	1
699-50-53A	Chloroform	ppb	8.8	5.0	10	4	2
699-50-53A	Chloromethyl methyl ether	ppb	10.0	10.0	10	2	1
699-50-53A	Chromium	ppb	22.0	6.0	90	11	10
699-50-53A	Chromium, filtered	ppb	9.8	3.0	20	8	4
699-50-53A	Cobalt	ppb	15.2	7.0	50	6	5
699-50-53A	Cobalt, filtered	ppb	13.0	4.0	20	4	2
699-50-53A	Cobalt-60	pCi/L	371.8	41.5	532	15	15
699-50-53A	Copper	ppb	25.7	7.0	107	7	7
699-50-53A	Copper, filtered	ppb	10.4	6.0	20	7	5
699-50-53A	Crotonaldehyde	ppb	10.0	10.0	10	2	1
699-50-53A	Cyanide	ppb	769.6	110.0	2710	24	24
699-50-53A	Cyanide, filtered	ppb	782.2	110.0	1690	18	18
699-50-53A	Di-n-butylphthalate	ppb	2.0	2.0	2	1	1
699-50-53A	Dibromochloromethane	ppb	7.5	5.0	10	2	1
699-50-53A	Dibromomethane	ppb	10.0	10.0	10	2	1
699-50-53A	Dichlorodifluoromethane	ppb	10.0	10.0	10	2	1
699-50-53A	Diethylarsine	ppb	10.0	10.0	10	2	1
699-50-53A	Ethyl methacrylate	ppb	10.0	10.0	10	2	1
699-50-53A	Ethylbenzene	ppb	7.5	5.0	10	2	1
699-50-53A	Ethylene oxide	ppb	3000.0	3000.0	3000	2	1
699-50-53A	Europium-154	pCi/L	1.3	.1	2	2	1
699-50-53A	Europium-155	pCi/L	1.2	.1	2	2	1
699-50-53A	Fluoride	ppb	1433.3	1000.0	1700	3	3
699-50-53A	Fluoride	ppm	1.8	1.8	2	1	1
699-50-53A	Fluorine	ppb	477.8	250.0	1020	18	17
699-50-53A	Formaldehyde	ppb	500.0	500.0	500	2	1
699-50-53A	Gross alpha	pCi/L	4.2	.8	9	22	20
699-50-53A	Gross beta	pCi/L	2257.9	424.0	3220	22	22
699-50-53A	Hexachlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	Hexachlorophene	ppb	10.0	10.0	10	2	1
699-50-53A	Hydrogen sulfide	ppb	10.0	10.0	10	2	1

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-50-53A	Iodine-129	pCi/L	.1	.0	0	5	3
699-50-53A	Iron	ppb	458.8	.4	1370	12	12
699-50-53A	Iron, filtered	ppb	327.8	265.0	406	12	12
699-50-53A	Kerosene	ppb	10000.0	10000.0	10000	2	1
699-50-53A	Lead	ppb	11.1	2.0	30	7	6
699-50-53A	Lead, filtered	ppb	8.0	2.0	20	4	2
699-50-53A	Magnesium	ppb	55940.0	79.6	79300	12	12
699-50-53A	Magnesium, filtered	ppb	69208.3	63000.0	89900	12	12
699-50-53A	Manganese	ppb	17.2	8.4	26	11	11
699-50-53A	Manganese, filtered	ppb	8.5	5.0	17	7	6
699-50-53A	Mercury	ppb	.1	.1	0	7	6
699-50-53A	Mercury, filtered	ppb	.1	.1	0	4	2
699-50-53A	Methacrylonitrile	ppb	10.0	10.0	10	2	1
699-50-53A	Methanethiol	ppb	10.0	10.0	10	2	1
699-50-53A	Methyl iodide	ppb	10.0	10.0	10	2	1
699-50-53A	Methyl bromide	ppb	10.0	10.0	10	2	1
699-50-53A	Methyl chloride	ppb	10.0	10.0	10	2	1
699-50-53A	Methyl ethyl ketone	ppb	10.0	10.0	10	2	1
699-50-53A	Methyl methacrylate	ppb	10.0	10.0	10	2	1
699-50-53A	Methylene chloride	ppb	8.5	4.0	10	4	2
699-50-53A	N,N-Diethylhydrazine	ppb	10.0	10.0	10	2	1
699-50-53A	N-Nitrosodiphenylamine	ppb	1.0	1.0	1	1	1
699-50-53A	Naphthalene	ppb	10.0	10.0	10	2	1
699-50-53A	Nickel	ppb	94.4	11.0	619	8	7
699-50-53A	Nickel, filtered	ppb	194.4	10.0	701	7	6
699-50-53A	Nitrate	ppb	524111.1	140000.0	625000	18	18
699-50-53A	Nitrate	ppm	665.0	665.0	665	1	1
699-50-53A	Nitrite	ppb	200.0	200.0	200	3	2
699-50-53A	Pentachlorobenzene	ppb	10.0	10.0	10	2	1
699-50-53A	Pentachloroethane	ppb	10.0	10.0	10	2	1
699-50-53A	Phenol	ppb	10.0	10.0	10	2	1
699-50-53A	Phosphate	ppb	742.9	400.0	1000	7	5
699-50-53A	Plutonium-238	pCi/L	.1	.1	0	5	4
699-50-53A	Plutonium-239/40	pCi/L	.0	.0	0	5	4
699-50-53A	Potassium	ppb	12981.1	13.0	17800	12	12
699-50-53A	Potassium, filtered	ppb	14933.3	13500.0	16800	12	12
699-50-53A	Potassium-40	pCi/L	128.3	96.6	160	2	2
699-50-53A	Pyridine	ppb	500.0	500.0	500	2	1
699-50-53A	Ruthenium-106	pCi/L	6.0	.1	31	15	13
699-50-53A	Selenium	ppb	33.6	17.5	61	11	11
699-50-53A	Selenium, filtered	ppb	26.4	19.0	33	6	6
699-50-53A	Silver	ppb	9.2	7.0	10	6	5
699-50-53A	Silver, filtered	ppb	10.1	4.0	20	7	5
699-50-53A	Sodium	ppb	50988.9	66.7	66600	12	12
699-50-53A	Sodium, filtered	ppb	59341.7	40600.0	66400	12	12

Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-50-53A	Specific conductance	umhos	1622.1	130.0	2450	14	14
699-50-53A	Strontium, filtered	ppb	1009.0	944.0	1150	9	9
699-50-53A	Strontium-90	pCi/L	.2	.0	0	8	7
699-50-53A	Styrene	ppb	7.5	5.0	10	2	1
699-50-53A	Sulfate	ppb	406384.6	380000.0	450000	13	13
699-50-53A	Sulfate	ppm	498.0	498.0	498	1	1
699-50-53A	Technetium-99	pCi/L	14634.6	391.0	32700	11	11
699-50-53A	Temperature, field	DegC	17.5	16.6	19	14	14
699-50-53A	Tetrachloroethene	ppb	6.3	5.0	10	4	2
699-50-53A	Thallium	ppb	5.7	2.0	20	7	6
699-50-53A	Thallium, filtered	ppb	3.5	2.0	5	2	1
699-50-53A	Tin, filtered	ppb	65.0	30.0	100	2	1
699-50-53A	Toluene	ppb	6.3	5.0	10	4	2
699-50-53A	Total Carbon	ppb	15650.0	14600.0	17200	4	4
699-50-53A	Total Organic Carbon	ppb	507.3	400.0	700	4	3
699-50-53A	Total Organic Halogen	ppb	[illegible]	4.7	9	2	1
699-50-53A	Tributylphosphoric Acid	ppb	10.0	10.0	10	2	1
699-50-53A	Trichloroethene	ppb	6.3	5.0	10	4	2
699-50-53A	Trichloromethanethiol	ppb	10.0	10.0	[illegible]	2	1
699-50-53A	Trichloromonofluoromethane	ppb	10.0	10.0	10	2	1
699-50-53A	Tritium	pCi/L	3220.7	470.0	5040	15	15
699-50-53A	Uranium	ppb	5.3	3.8	8	5	5
699-50-53A	Uranium-234	pCi/L	2.4	2.4	2	1	1
699-50-53A	Uranium-235	pCi/L	.1	.1	0	1	1
699-50-53A	Uranium-238	pCi/L	2.0	2.0	2	1	1
699-50-53A	Vanadium	ppb	31.7	10.7	53	11	11
699-50-53A	Vanadium, filtered	ppb	9.1	5.0	30	9	7
699-50-53A	Vinyl chloride	ppb	10.0	10.0	10	2	1
699-50-53A	Xylenes (total)	ppb	6.3	5.0	10	4	2
699-50-53A	Zinc	ppb	14.3	6.0	23	10	10
699-50-53A	Zinc, filtered	ppb	10.5	6.0	32	9	9
699-50-53A	Zinc-65	pCi/L	4.3	.1	8	2	1
699-50-53A	Zirconium/Niobium-95	pCi/L	16.6	12.5	21	2	1
699-50-53A	cis-1,3-Dichloropropene	ppb	7.5	5.0	10	2	1
699-50-53A	pH	pH	7.7	7.0	8	21	21
699-50-53A	trans-1,2-Dichloroethylene	ppb	10.0	10.0	10	2	1
699-50-53A	trans-1,3-Dichloropropene	ppb	7.5	5.0	10	2	1
699-50-53A	trans-1,4-dichloro-2-butene	ppb	10.0	10.0	10	2	1
699-52-54	1,1,1-Trichloroethane	ppb	7.5	5.0	10	2	1
699-52-54	1,1,2-Trichloroethane	ppb	7.5	5.0	10	2	1
699-52-54	1,1-Dichloroethane	ppb	7.5	5.0	10	2	1
699-52-54	1,1-Dichloroethene	ppb	7.5	5.0	10	2	1
699-52-54	1,2-Dichloroethane	ppb	7.5	5.0	10	2	1

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Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-52-54	1,2-Dichloroethene	ppb	7.5	5.0	10	2	1
699-52-54	1,2-Dichloropropane	ppb	7.5	5.0	10	2	1
699-52-54	2-Hexanone	ppb	10.0	10.0	10	2	1
699-52-54	4-Methyl-2-pentanone	ppb	10.0	10.0	10	2	1
699-52-54	Acetone	ppb	8.0	4.0	12	2	1
699-52-54	Aluminum	ppb	89.8	46.0	236	9	8
699-52-54	Antimony	ppb	36.9	5.4	63	7	6
699-52-54	Antimony, filtered	ppb	37.0	19.0	55	2	1
699-52-54	Arsenic	ppb	5.5	3.8	6	10	10
699-52-54	Arsenic, filtered	ppb	6.1	5.5	7	2	2
699-52-54	Barium	ppb	45.3	37.7	58	10	10
699-52-54	Barium, filtered	ppb	39.4	36.6	42	2	2
699-52-54	Benzene	ppb	7.5	5.0	10	2	1
699-52-54	Beryllium	ppb	1.0	1.0	1	6	5
699-52-54	Beryllium, filtered	ppb	1.0	1.0	1	2	1
699-52-54	Bis(2-ethylhexyl) phthalate	ppb	1.0	1.0	1	1	1
699-52-54	Bromodichloromethane	ppb	7.5	5.0	10	2	1
699-52-54	Bromoform	ppb	7.5	5.0	10	2	1
699-52-54	Cadmium	ppb	4.3	3.0	7	6	5
699-52-54	Cadmium, filtered	ppb	4.0	4.0	4	2	1
699-52-54	Calcium	ppb	70180.0	60200.0	81700	10	10
699-52-54	Calcium, filtered	ppb	61150.0	59800.0	62500	2	2
699-52-54	Carbon disulfide	ppb	7.5	5.0	10	2	1
699-52-54	Carbon tetrachloride	ppb	7.5	5.0	10	2	1
699-52-54	Chlorobenzene	ppb	7.5	5.0	10	2	1
699-52-54	Chloroethane	ppb	10.0	10.0	10	2	1
699-52-54	Chloroform	ppb	7.5	5.0	10	2	1
699-52-54	Chromium	ppb	17.7	6.0	37	10	9
699-52-54	Chromium, filtered	ppb	5.2	4.0	6	2	1
699-52-54	Cobalt	ppb	7.7	4.0	10	6	5
699-52-54	Cobalt, filtered	ppb	6.0	4.0	8	2	1
699-52-54	Copper	ppb	22.8	6.0	130	9	8
699-52-54	Copper, filtered	ppb	6.5	6.0	7	2	1
699-52-54	Cyanide	ppb	76.1	10.0	169	6	5
699-52-54	Dibromochloromethane	ppb	7.5	5.0	10	2	1
699-52-54	Ethylbenzene	ppb	7.5	5.0	10	2	1
699-52-54	Iron	ppb	579.8	62.1	1550	10	10
699-52-54	Iron, filtered	ppb	47.8	36.0	60	2	1
699-52-54	Lead	ppb	2.0	2.0	2	6	5
699-52-54	Lead, filtered	ppb	2.0	2.0	2	2	1
699-52-54	Magnesium	ppb	21720.0	19700.0	24500	10	10
699-52-54	Magnesium, filtered	ppb	20000.0	19800.0	20200	2	2
699-52-54	Manganese	ppb	14.5	3.1	33	10	10
699-52-54	Manganese, filtered	ppb	3.4	3.0	4	2	1
699-52-54	Mercury	ppb	.1	.1	0	6	5

Well	Constituent Name	Units	Results Summary Average	Minimum	Maximum	Analysis Summary Total	> D.L.
699-52-54	Mercury, filtered	ppb	.2	.1	0	2	1
699-52-54	Methyl bromide	ppb	10.0	10.0	10	2	1
699-52-54	Methyl chloride	ppb	10.0	10.0	10	2	1
699-52-54	Methyl ethyl ketone	ppb	10.0	10.0	10	2	1
699-52-54	Methylene chloride	ppb	13.5	2.0	25	2	2
699-52-54	Nickel	ppb	17.3	10.1	25	8	7
699-52-54	Nickel, filtered	ppb	8.5	7.0	10	2	1
699-52-54	Potassium	ppb	9467.0	8580.0	10400	10	10
699-52-54	Potassium, filtered	ppb	8535.0	8080.0	8990	2	2
699-52-54	Selenium	ppb	10.8	7.5	13	10	10
699-52-54	Selenium, filtered	ppb	11.1	9.6	13	2	2
699-52-54	Silver	ppb	7.7	4.0	10	6	5
699-52-54	Silver, filtered	ppb	5.5	4.0	[illegible]	2	[illegible]
699-52-54	Sodium	ppb	380[illegible].0	35100.0	40800	[illegible]	10
699-52-54	Sodium, filtered	ppb	36500.[illegible]	36500.0	36500	2	2
699-52-54	Specific conductance	umhos	666.6	573.0	829	[illegible]	[illegible]
699-52-54	Styrene	ppb	7.5	5.0	10	2	1
[illegible]-52-54	[illegible]perature, field	Deg[illegible]	1[illegible].7	17.0	19	5	5
699-52-54	Tetrachloroethene	ppb	[illegible].5	5.0	10	2	1
699-52-54	Thallium	ppb	2.5	2.0	5	6	5
699-52-54	Thallium, filtered	ppb	3.5	2.0	5	2	1
699-52-54	Toluene	ppb	7.5	5.0	10	2	1
699-52-54	Trichloroethene	ppb	7.5	5.0	10	2	1
699-52-54	Vanadium	ppb	26.7	8.0	43	10	9
699-52-54	Vanadium, filtered	ppb	21.7	8.0	35	2	1
699-52-54	Vinyl chloride	ppb	10.0	10.0	10	2	1
699-52-54	Xylenes (total)	ppb	7.5	5.0	10	2	1
699-52-54	Zinc	ppb	16.9	6.1	65	10	10
699-52-54	Zinc, filtered	ppb	5.5	5.2	6	2	2
699-52-54	cis-1,3-Dichloropropene	ppb	7.5	5.0	10	2	1
699-52-54	pH	pH	7.8	7.0	8	7	7
699-52-54	trans-1,3-Dichloropropene	ppb	7.5	5.0	10	2	1

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ATTACHMENT 1

METRIC CONVERSION CHART

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Metric Conversion Chart

The following conversion chart is provided to the reader as a tool to aid in conversion.

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
short ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	short ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit

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